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THE EMPEROR WILLIAM AND HIS FAMILY.

FRIEDRICH WILHELM, or William II., as he is usually called, the present Emperor of Germany and King of Prussia, is the eldest son of the late Emperor Friedrich III. and Victoria, Princess Royal of England, daughter of Queen Victoria and Prince Albert. The Emperor William was born January 27, 1859, and was educated at the Gymnasium of Cassel, submitting to the ordinary discipline of that excellent educational institution. In 1877 he was sent to the University of Bonn, which is situated on the Rhine, near Cologne. On his twenty-second birthday (1881) he married the Princess Augusta Victoria of Schleswig-Holstein-Augustenburg, a niece of Prince Christian. William II. is the third emperor of the present German empire, which was founded April 16, 1871. His grandfather, William I., died March 9, 1888. Friedrich reigned but little more than three months, dying June 15, 1888. William II. then succeeded to the throne.

The emperor has great power—the right and duty

THE EMPEROR WILLIAM AND HIS FAMILY.

of representing the empire for all purposes of international law devolving upon him. The emperor also declares war and peace, and is the commander-in-chief of the army and navy in time of war, and also, with trifling exceptions, in time of peace. His edicts are made in the name of the empire, and must be signed by the chancellor.

The principal events which have occurred in Germany since the present emperor succeeded have been, first, the rise of the anti-semitic movements, which resulted in the exposure of stupendous frauds; second, the system of uniform time, which was adopted March 31, 1893; thenceforth the mid-European time—that of the 15th degree of longitude east of Greenwich, obtains all over the country; the army bill; and lastly, his trouble with Bismarck and his reconciliation to the "Iron Chancellor," which is still fresh in the memory of all. The emperor is very fond of traveling, and considerable time each year has been spent in paying visits, catching whales, etc. In 1890 his imperial majesty paid a state visit to Heligoland; in 1891 to Amsterdam, and later in the year, accompanied by the empress, he visited England, where he was fêted and presented with the freedom of the City of London.

In April, 1893, the emperor attended the silver wedding of the King and Queen of Italy, and took this opportunity of visiting Pope Leo XIII. In July of the same year he won the Queen's Cup in the races at Cowes. The total income of the emperor is about 15,719,000 marks, or $3,752,000.

The emperor has seven children. The eldest, the Crown Prince of Germany and Prussa, is Prince Friedrich-Wilhelm-Victor-August-Ernst, born May 6, 1882. The second child is Prince Wilhelm-Eitel-Friedrich-Christian-Karl, born July 7, 1883. The third is Prince Adalbert-Ferdinand-Berenger-Victor, born July 14, 1884. Prince August-Wilhelm-Heinrich-Victor was born January 29, 1887. The fifth child, Prince Oscar-Karl-Gustav-Adolf, was born July 27, 1888. The sixth child is Prince Joachim-Francois-Humbert. He was born December 17, 1890. The youngest is a girl, Princess Victoria-Louise-Adelaide-Mathilde-Charlotte. She was born September 13, 1892. The emperor has one brother and four sisters. For our illustration we are indebted to *Illustrirte Zeitung*.

CEMENT TESTING.

By SPENCER B. NEWBERRY.

THE manufacture of hydraulic cement is an operation requiring the greatest care and skill. The selection, preparation and mixing of the raw materials, the burning of the charge, and the sorting and grinding of the product, must all be carefully controlled, or serious defects in the finished cement will result. The faults shown by bad cements are, moreover, generally not trifling ones, nor immediately evident, but often consist of hidden and dormant evils, which may cause the failure and destruction of important pieces of engineering work after the lapse of months or years. It is evident, therefore, that simple and rapid methods of detecting these hidden faults, and of determining the comparative values of different samples of cement, are absolutely indispensable to all engaged in the many kinds of constructive work in which cement is used.

The chief uses of hydraulic cement are in making concrete foundations, mortar for brick and stone, sidewalks and flooring, cistern, reservoir and aqueduct linings, and in a variety of lesser applications, such as sewer pipes, tiles, and architectural ornaments. These uses require various qualities, among which the most important are probably the following:

Setting and hardening properties.
Strength under tension and compression.
Permanence in water and in air.

These are the qualities for which cements are usually tested, and may be simply and quickly determined. Other necessary qualities, such as resistance to wear, resistance to frost, impermeability to water, and adhesion to brick or stone, may generally be assumed to be present in satisfactory degree in cements which stand the usual tests, and depend to a great extent on the manner in which the cements—even those of best quality—are used.

The testing of cements, especially for tensile strength, is a delicate operation, and requires care and practice. The proportion of water used, thoroughness of mixing, temperature of the testing room, and manner of filling the moulds, must all be carefully noted and made uniform, or the results will show nothing but confusion. For this reason certain definite requirements and instructions for testing have been adopted as a standard in different countries. In the United States, the requirements of the New York Department of Docks and the Engineer Department of the District of Columbia are official statements of the qualities which good cements should show, but give little information as to methods of testing. The report of the Special Committee of the American Society of Civil Engineers (June, 1885) contains many valuable suggestions in regard to the manner in which the tests should be made. In Germany, the requirements of the Prussian Minister of Public Works are the recognized standard, and contain full and definite specifications as to methods of testing. The same is true of the official French requirements, which are those of the *Services Maritimes des Ponts et Chaussées*. It is remarkable that in England, the birthplace of the Portland cement industry, no agreement in regard to requirements or methods of testing has ever been reached.

It is the purpose of this paper to give a brief synopsis of these various requirements, together with a few notes taken from the author's own experience, in the hope that the matter thus presented may prove a convenience to American engineers. In stating the standard requirements of the United States, Germany and France, only a brief abstract is given, and all details which seem to the author to be unimportant are omitted. References are given, however, to the full text of the published specifications.

REQUIREMENTS OF THE NEW YORK DEPARTMENT OF DOCKS, 1891.

Time of Setting to be determined by a wire $\frac{1}{12}$ inch in diameter, loaded to weigh one pound. Quick setting cement must set within one-half hour; slow setting cement must not set within one-half hour.

Fineness must be such that at least 90 per cent. shall pass a sieve of 50 meshes to the inch.

Tensile Strength.—Neat cement, 7 days (one day in air and six in water), at least 300 lb. Cement with two parts sand, 7 days, at least 125 lb.

Constancy of Volume.—A pat of the cement, on glass, placed in water when set, must show no cracks or distortions. A similar pat, when set, is exposed to steam at about 200° for 3 hours, then placed in boiling water for 24 to 48 hours, and must still adhere to the glass and show no cracks or distortions.

SPECIFICATIONS OF THE ENGINEER DEPARTMENT, DISTRICT OF COLUMBIA.

Natural Cement.

Fineness.—Not less than 92 per cent. to pass a 50 mesh sieve, and not less than 80 per cent. to pass a 100 mesh sieve.

Time of Setting.—Initial set in not less than 10 nor more than 45 minutes.

Tensile Strength.—1 day (in air until set, rest of day in water), neat, 50 lb.; 7 days (1 day in air, 6 days in water), neat, 100 lb.; with two parts sand, 50 lb.; 28 days, neat, 150 lb.; with two parts sand, 100 lb.

Portland Cement.

Fineness.—Not less than 95 per cent. to pass a 50 mesh sieve, and not less than 85 per cent. to pass a 100 mesh sieve.

Time of Setting.—Initial set in not less than one hour.

Tensile Strength.—1 day, neat, 125 lb.; 7 days, neat, 400 lb.; with three parts sand, 100 lb.; 28 days, neat, 500 lb.; with three parts sand, 150 lb.

Constancy of Volume.—Portland cement shall not contain more than 3 per cent. of free lime, and shall withstand without cracking a temperature of 212 F. after immersion in water for 24 hours.

RECOMMENDATIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

The society appointed a committee to devise a uniform system for testing hydraulic cement. The report of this committee, presented at the annual meeting, January 21, 1885, is published in the Proceedings of the Society, June, 1885, and reprinted in full in the SCIENTIFIC AMERICAN SUPPLEMENT, January 30, 1886. This report is generally regarded as the chief standard of reference among American engineers. The recommendations given are, however, chiefly general in character, and allow a good deal of latitude in methods of testing. The following are some of the most important recommendations contained in the report.

Fineness.—Cement of the better grades is now usually ground so fine that only from five to ten per cent. is rejected by a sieve of 2,500 meshes per square inch (50 mesh). The finer the cement, if otherwise good, the larger dose of sand it will take, and the greater its value.

Checking or Cracking.—Make two cakes of cement, two to three inches in diameter, ½ inch thick, mixed with water to the consistency of stiff plastic mortar. Note the time required to set hard enough to stand the wire test recommended by Gen. Gillmore, $\frac{1}{12}$ inch diameter loaded with ¼ lb., and $\frac{1}{24}$ inch diameter loaded with one lb. One of these cakes, when hard enough, is placed in water and examined from day to day to see if it becomes contorted or cracked. The remaining cake should be kept in air and its color observed.

Tensile Strength.—Cements are to be tested neat, natural cement also with one part sand; Portland cement with three parts sand. The amount of water required is approximately as follows: neat natural cement, 30 per cent.; neat Portland cement, 25 per cent. cement with one part sand, 15 per cent. of total weight; with three parts sand, 12 per cent. The mixing must be rapid and thorough; the mortar, which should be stiff and plastic, should be firmly pressed into the moulds with the trowel, without ramming, and struck off level.

The temperature of the briquettes and of the testing room should be constant between 60° and 70° F.

The sand recommended is the *crushed quartz* used in the manufacture of sand paper, of such fineness as to pass a 20 mesh sieve and be caught on one of 30 meshes.

The report includes drawings of the standard form of briquette recommended for adoption, which is now universally used in this country. Diagrams of moulds and clips and descriptions of the same are also given. A table of the average results of tests of natural and Portland cements, neat and with sand, is included. The figures for Portland cement are, however, greatly below those ordinarily given by the best grades at present on the market, and indicate that great improvement in the quality of cement has taken place during the past nine years.

GERMANY—REQUIREMENTS OF THE PRUSSIAN MINISTER OF PUBLIC WORKS.*

Time of Setting.—Slow setting cements are those which set in not less than two hours. The time of setting is tested by making a pat of the cement, about one-half inch thick, with thin edges, on a plate of glass. The amount of water used should be such as to require several taps of the plate on the slab to cause the cement to spread to the edges; usually 27 to 30 per cent. water will give this result. The temperature of the room and of the water used should be from 15° to 18° C. (59° to 65° F.) The cement is considered to be set when it resists a light pressure of the finger nail.

Exact determinations are made by means of a normal needle of 1 square millimeter section (= $\frac{1}{12}$ inch diameter) weighing 300 grammes (10½ ounces). A metal ring 4 centimeters (1⅝ inches) high and 8 centimeters (3 ⅛ inches) inside diameter is placed on glass and filled with cement paste of the above consistency. The time at which the needle ceases to pass entirely through the cement is called the *initial set*. The time which has passed when the needle ceases to make a noticeable impression represents the *time of setting*.

Portland cement becomes slower setting by long storage, and if kept dry gains in strength. Specifications requiring fresh cement are therefore erroneous, and should be abandoned.

Constancy of Volume.—Portland cement must show no increase of volume in setting and hardening. This is to be determined by means of a pat of cement on glass as described for the determination of time of setting. Such a pat is kept for 24 hours in a closed box or under a damp cloth, then laid in water. After long periods it must show no radial cracks at the edges nor changes of form. The appearance of radial cracks or curving of the pat is proof of expansion of the cement. These generally appear, if at all, during the first three days; observation for 28 days is in all cases sufficient.

Fineness of Grinding.—Not more than 10 per cent. should remain on a sieve of 900 meshes per square centimeter (76 meshes to the linear inch) in which the diameter of the wire is one-half the width of the mesh.

Strength under Tension and Compression.—This is to be determined by tests of a mixture of cement and sand. Tests of neat cement are also recommended. Portland cement, with three parts sand, by weight, must show after 28 days (one day in moist air and 27 days in water) a tensile strength of at least 16 kilogrammes per square centimeter (227 lb. per square inch), and a compression strength of 160 kg. per sq. cm. (2,270 lb. per square inch). Washed quartz sand, which passes a sieve of 20 meshes to the linear inch, and is retained by one of 30 meshes, is to be used. This is to be compared as to results with the German normal sand (from Freienwalde on the Oder) furnished by the Royal testing station at Charlottenburg.

Briquettes are to be made as follows: For five briquettes weigh out 250 g. (9 oz.) cement and 750 g. (27 oz.) sand. Mix dry, add 100 c. c. water (3½ oz. by weight = 10 per cent.) and work strongly five minutes. The mixture is pressed into the moulds so as to fill them above the top, and pounded for at least one minute each with an iron spatula, at first gently from the sides, then more strongly, until the mass becomes elastic and water appears on the surface. The spatula should be 14 inches long, the blade 1½ by 2 inches, and should weigh about 250 g. (9 oz.) Briquettes are to be kept in a zinc-lined box for 24 hours, then placed in water

Briquettes may also be made by means of Dr. Bohme's hammer apparatus. One hundred and fifty blows on each briquette are automatically given, the hammer weighing 2 kilogrammes.

Test pieces for compression are to be of cubical form, 50 square centimeters (7¾ square inches) on a side. These are to be made of a mixture of cement with 3 parts sand, with 10 per cent. water. The moulds are to be filled by means of the hammer apparatus.

All tests are to be made immediately on taking the test pieces from the water. In tests of tensile strength the weight should be applied at the rate of 100 grammes (3½ oz.) per second.* The average of ten tests shall be taken as the correct tensile strength.

FRANCE—REQUIREMENTS OF THE SERVICES MARITIMES DES PONTS ET CHAUSSEES †

Density.—A liter measure is loosely filled with cement, previously screened through a sieve of 100 meshes to the linear inch and weighed. (This test is used for comparison of different lots of the same cement, the weight of 1 liter of which must exceed a certain figure determined for the cement in question. No general requirement as to density is made.)

Chemical Composition.—Cement containing more than 1 per cent. of sulphuric anhydride (= 1·7 per cent. sulphate of lime) is rejected, while that containing more than 4 per cent. of oxide of iron is declared suspicious. Cement containing less than 44 parts of silica plus alumina to 100 of lime is also considered suspicious.

Time of Setting.—Room and water used are to be at temperature of 15° to 18° C (59° to 65° F.) The cement and water to be mixed 5 minutes with a trowel of stated dimensions; proportion of water to be such that a small quantity of the mixture will fall from the trowel without leaving any adhering portions, and if dropped on the slab from a height of about 20 inches will retain its form and show no cracks. The test for time of setting is made by filling a metal ring as described in the German requirements. The needle employed has a square section of 1 millimeter ($\frac{1}{25}$ inch), and carries a weight of 300 grammes. Cement which begins to set in less than 30 minutes or sets completely in less than 3 hours is refused.

Constancy of Volume.—Pats on glass are immersed in *sea water*, kept at temperature of 59° to 65° F., and examined for cracking or change of form.

Tensile Strength.—Briquettes of neat cement are to be made with the proportion of water used in the test for time of setting, worked strongly with the trowel for 5 minutes. The moulds are to be filled by pressing the cement in with the trowel, then tapped lightly on the sides to soften the mixture and disengage air bubbles. The surface is then smoothed off with a flat knife blade. The moulds are removed when the cement is set, and the briquettes kept for 24 hours in moist air, then put in water. Temperature to remain constant as given above. Tests are to be made at 7 days, 28 days, and 12 weeks. The tensile strength at 7 days must be at least 20 kilog. per sq. cm. (284 lb. per sq. in.); at 28 days, 35 kilog. per sq. cm. (497 lb. per sq. in.); at 12 weeks, 45 kilog. per sq. cm. (639 lb. per sq. in.). The tensile strength at 28 days must exceed that at 7 days by at least 5 kilog. per sq. cm. (71 lb. per sq. in.); the tensile strength at 12 weeks must be greater than that at 28 days unless the latter shall be at least 55 kilog. per sq cm. (781 lb. per sq. in.)

Sand tests are to be made with three parts sand by weight, with 12 per cent. water. The sand to be used is *crushed quartz* from the Cherbourg quarries, passing a 20 mesh and remaining on a 30 mesh sieve. The moulds are filled by pounding with a spatula of prescribed size and weight, as in the German requirements. The tensile strength with three parts sand must be at 7 days at least 8 kilog. per sq. cm. (114 lb. per sq. in.); at 28 days at least 15 kilog. per sq. cm. (213 lb. per sq. in.); and at 12 weeks 18 kilog. per sq. cm. (256 lb. per sq. in.) The strength at 12 weeks must in all cases be greater than that at 28 days.

NOTES ON THE FOREGOING METHODS OF TESTING.

The report of the Committee of the Society of Civil Engineers contains the following very just paragraph:

* "Portland Cement und seine Anwendungen im Bauwesen," Berlin, 1892, p. 36.

* In an ordinary Fairbanks testing machine the actual weight used is multiplied by 100. According to this the time required to break a briquette should be about five seconds for every 100 pounds of tensile strength.

† Candlot, "Ciments et Chaux Hydrauliques," Paris, 1891, p. 150.

"The testing of cement is not so simple a process as it is sometimes thought to be. No small degree of experience is necessary before one can manipulate the materials so as to obtain even approximately accurate results. The first tests of inexperienced, though intelligent and careful, persons are usually very contradictory and inaccurate, and no amount of experience can eliminate the variations introduced by the personal equations of the most conscientious observers. Many things, apparently of minor importance, exert such a marked influence upon the results that it is only by the greatest care in every particular, aided by experience and intelligence, that trustworthy tests can be made."

It is undoubtedly true that engineers often belittle and neglect necessary precautions in testing cement. Far too many have their own special methods, often giving quite unfair results, and pay little attention to the suggestions and warnings of experts who have gone deeply into the subject. On the other hand, it is not to be expected that practical cement testers will follow the exact methods and employ the delicate instruments needed for scientific research. Simple and plain methods must be devised, and no precautions insisted upon which do not certainly and greatly affect the results. The following notes, taken from the writer's own experience, are offered in the interest of simplicity and uniformity in methods of testing.

Fineness of Grinding.—It is well known that only the finest dust of cement has any great setting and hardening power; the coarser particles, even those passing a fine screen, but gritty in feeling and dark in color, act merely like sand. For this reason, the finer the sieve used in testing, the more significant the results will be. A cement might, for example, be so ground as all to pass an 80 mesh sieve, and yet contain but little dust. Of two cements, the one showing the largest residue on an 80 mesh sieve might contain the larger proportion of dust, and be really the better ground.

The following table, taken from the records of the laboratory for cement testing at Cornell University, shows the results which several cements gave when tested with sieves of different grades.

Percentage Remaining on Various Sieves.

Meshes per inch.	Meshes per square inch.	Dykerhoff (German).	K. B. & S. (English).	White's (English)	American.	American.
50	2,500	0·6	10·8	7·2	4·3	0·5
80	6,400	6·2	12·5	10 8	10·1	14·1
180	32,400	23·5	14·3	14·9	19·4	26·0
Dust.	....	62·7	62·4	67·1	66·2	59·4

It will be seen that the first and last of these cements, though giving the best results when tested with a coarse screen, are really inferior to the others in actual pescentage of impalpable powder.

The presence of a few per cent. of coarse material, or the addition of a few per cent. of sand, actually *increases* the tensile strength of neat cement. With *two* or three parts sand, however, the superiority of well ground cement appears most strikingly, the results being nearly in proportion to the amount of fine dust present. It should be remembered, however, that soft, light-burned cements are much more easily ground fine than those which are hard and well burned. The fineness should therefore be considered in connection with the results of other tests.

Color, etc.—The color of a cement is often considered as an indication of its quality. This is only partially correct. Cements are light or dark according to the amount of iron present in the materials, a mixture rich in iron oxide giving a dark cement, while materials nearly free from iron give a light colored product. Some of the best German cements are, however, decidedly dark. A brown tint in Portland cement generally indicates too light burning or defective combination of the iron from other causes. Natural rock cements, which are very lightly burned, are all more or less brown. The color of cement after hardening in water is important, as the occurrence of brownish patches indicates poor quality. A dark bluish-green color is sometimes seen on the back of pats of cement which have hardened on glass or in the interior of freshly broken briquettes. This is due to the presence of sulphides, due to too much sulphate of lime in the materials, combined with bad burning. Such cement gives weak tests, especially with sand.

Constancy of Volume.—The tendency of cement to expand or crack is the most dangerous of all the faults it can show, since this may in time cause the destruction of the work in which the cement is used. The pat test on glass is generally relied upon to detect this fault, and should never be omitted. Care should be taken not to put the pats in water until thoroughly set, as the best cements will fail if put in water too soon. For the sake of uniformity it is best to keep the pats for 24 hours under a damp cloth or in a closed box before putting in water. The amount of water used in mixing should not be too great, or the cement will not harden well. The amount specified in the German requirements will be found suitable. The cracks due to expansion occur usually at the edges of the pat, and radiate from the center. These should not be confused with irregular shrinkage cracks, which show themselves when the pats are made too wet and allowed to dry out too much during setting.

The tendency to expand and crack shows itself much sooner and more distinctly in the pats than in briquettes. Nevertheless the inspection must be continued for a long time, if all possibility of future failure is to be avoided. The writer has known cases in which the pats stood satisfactorily for two weeks or more, but briquettes of the same cement went to pieces after several months. The dangerous expansion of cement is due to free or imperfectly combined lime, resulting generally from coarseness or imperfect mixture of the raw materials. The slaking of this lime is often very long delayed, but finally takes place with irresistible force, completely destroying the hardened cement and the work done with it.

For the purpose of quickly determining any tendency of cement to expand and crack, the *hot test* is largely used. This consists in exposing the pats, after setting, to the action of steam for several hours, then placing them in boiling water for some hours more. Capt. W. W. Maclay, chief of the New York Department of Docks, has lately made a study of this test; a full description of the method he recommends is to be found in the Proceedings of the American Society of Civil Engineers, October, 1892. Capt. Maclay advises placing several pats in steam; one freshly made, one after setting, and two at longer periods; after three hours' exposure to steam, each is kept in boiling water for twenty-one hours. The action of steam quickly slakes the free lime, if present, causing the pats to swell, crack, and often to fall to powder. This test has been wholly rejected by the association of German cement makers, on the ground that it is too severe, since many cements which fail under this test prove faultless in use, even after long periods. This is doubtless more or less true, and yet the hot test errs on the side of safety, and is a valuable aid to the engineer in detecting distinctly dangerous cements. The writer believes that three hours' exposure to steam is amply sufficient for all practical purposes, and that the boiling water test is unnecessary. A few trials will convince any one that no cement which cracks in cold water, even after months, can possibly stand the test in steam for three hours. The fact is that no cement is wholly free from uncombined lime, and that a very small percentage of this is entirely harmless. Such a proportion as would be dangerous in practical work is immediately and strikingly detected by the test in steam, and much more surely than by long tests in cold water.

In using the hot test, care should be taken not to make the pats too wet, since excess of water causes even the best cements to swell up and soften under the action of hot steam. The writer has found that exposure to steam after setting is a more searching test than that of placing in steam as soon as made. In the latter case slaking of the free lime appears often to take place before the setting, and the fault thus escapes detection. Pats of sound cement placed in steam after setting will harden rapidly, and show no cracking or crumbling; they will also generally remain attached to the glass, though this point is usually not regarded as essential, since the best cements vary greatly in this respect.

Tensile Strength.—Many engineers depend entirely on tensile strength tests in judging of the quality of a cement, and confine their tests to those of neat cement at short periods. This is not good practice, for several reasons. Cements which are very high in lime, and even those showing a tendency to crack, often give remarkable neat tests at short periods. The highest one-day and seven-day breaks the writer has ever seen were given by cements which went entirely to pieces at 28 days, and failed utterly in the hot test. Such cements always give very low results when tested with three parts of sand. Neat tests are in all cases more or less deceptive, since many cements which give very poor results with sand pass the neat test without difficulty. For this reason, the only test officially recognized in Germany is the test with three parts sand at twenty-eight days. Neat tests, if made, should always be taken in connection with pat tests for constant volume, since the latter will show whether the strength of the cement at short periods is legitimate or not. The *best cements*, as shown by their reputation, are not those which give astonishing breaks at one or seven days, but are rather those which show a fair strength at first, and a steady gain through long periods. The demand for high breaks within the first few days has led manufacturers to raise the percentage of lime in their cements to the highest possible point, since only in this way can such tensile precocity be secured. This brings them near the danger line, however, and opens the way to defects of the gravest kind.

In making briquettes, a number of precautions must be observed, or the results will be wholly misleading.

The proportion of water used greatly affects the resulting strength. Enough water should be taken to make a stiff, plastic mixture; more than this weakens the briquettes, especially when tested at short periods. For quick setting natural rock cement, about 30 per cent. of water will generally be required. Portland cement requires from 22 to 25 per cent. With three parts sand, water to the amount of 10 per cent. of the weight of the mixture, as specified in the German requirements, will be found about correct. In work so necessarily exact as this, the use of French weights and measures will be found an immense saving of labor and tedious calculation. The cement and sand are weighed in grammes and the water measured in cubic centimeters. Since one cubic centimeter of water weighs one gramme, the correct percentage may at once be taken without calculation.

The temperature of the testing room, the water used for mixing, and the water in which the briquettes are kept, greatly influence the results, especially at short periods. Cement which shows 150 lb. in one day when briquettes are made and kept in a fairly warm room may easily show as low as 50 lb. when made and set in a room near the freezing point. A constant temperature of 70° or thereabout is essential.

The thoroughness of mixing the cement and water makes a most surprising difference. The German requirements specify that the mixture for sand briquettes shall be "strongly worked with the trowel for five minutes." The writer found, in one case, that a cement with 3 per cent. of sand, worked about one minute, gave at seven days 87 lb.; the same mixture, thoroughly worked five minutes, gave in seven days 240 lb. With neat cement thoroughness of mixing is equally necessary. Doubtless, many failures and variations in results are due to neglect of this precaution. Rubbing the moist mixture in a large porcelain mortar for a few moments before filling each mould is practiced by some. This method gives higher results, and, if adopted, should be uniformly followed.

The manner of filling the moulds, also, greatly affects the results. In the writer's opinion, briquettes of neat cement should be made by pressure of the thumbs alone, rubber finger caps being worn for protection. The mixture should be stiff enough to allow a fair pressure to be applied without forcing the mortar out of the mould. This method has been found to give more uniform results than any other. Pounding the cement into the moulds is a bad practice. Very high breaks may be obtained in this way, especially if very little water be used, but the results will vary immensely with the amount of pounding, and indicate little or nothing in regard to the quality of the cement. Making the mixture very wet (25 to 26 per cent. water) and filling the moulds with the trowel alone, is recommended by many. The results obtained in this way are lower, and liable to vary greatly on account of unavoidable air bubbles. Whichever method is adopted, it should be rigidly adhered to, and the results checked by tests of cements of known good quality.

In tests with sand a certain amount of pounding is essential to the production of sound briquettes. The German and French specification of a spatula of certain size and weight is a very good one. Instead of this, a fairly heavy trowel will give good results, or a block laid on and lightly rapped with a mallet.

In regard to the kind of sand to be used, it may be mentioned that the German standard sand consists of more or less rounded grains, rough on the surface. The American standard crushed quartz is, on the other hand, composed of sharp and glossy splinters, which lie very loosely together, the air spaces between the grains being much greater than in the German standard or any other natural sand. For this reason, the American standard quartz gives decidedly lower results than an ordinary building sand. In the writer's judgment its use is objectionable on this account. A pure quartz sand, of proper fineness, is preferable for practical work, as it more nearly represents the results the cement will give in use.

Testing Machines.—Those in common use are of two types. In one the weight is applied by a stream of shot which runs from a reservoir into a pail suspended at the end of the steelyard arm; when the briquette breaks the arm falls, automatically cutting off the flow of shot. In the other type a heavy weight is slowly drawn along the beam by a cord wound on a wheel turned by the operator. The former type is that officially recognized in Germany and France, and is decidedly preferable on account of its greater simplicity, smaller bulk and regular application of the weight. The ponderous and costly weight machines, in which the weight is more or less jerkily propelled at any speed the operator may fancy, appear not to be used outside of this country.

An important point in any machine is the form of the jaws which hold the briquette. If made to fit closely over a considerable surface, the briquettes will be crushed, not broken, across the smallest section. The jaws should be cut away so as to touch the briquette only along a broad line on each side. A strip of tin, bent to fit inside of each jaw, is a great help in giving clean breaks at the smallest point of the briquettes.

Compression tests are not commonly made in this country, owing to the rather expensive apparatus required. They are, however, very necessary in case of work of great magnitude. The tensile strength of cement is generally assumed to indicate the compression strength with fair accuracy, as it has been found that cements of good quality usually show a resistance to compression equal to about ten times the tensile strength on a given section. In quick-setting and natural rock cements the compression strength is relatively lower.

Apparatus Needed for Testing Cements.—The following may be considered a fair equipment for ordinary tests:

A slab of slate or marble, at least two by three feet in size, one and a half inches thick.

A grocer's scale, weighing to one-fourth ounce.

Set of weights, preferably on the metric system.

A glass graduate for measuring water, preferably showing cubic centimeters.

A trowel with five-inch blade.

Pieces of glass, about five inches square, for pats, and some about three inches square for hot tests.

Testing machine and at least one dozen moulds.

A trough for keeping briquettes in water, best lined with zinc.

A square copper box on legs for hot tests, with gas burner, rack for pats, and cover.

SPEED VERSUS ECONOMY IN STEAM VESSELS.

AT a recent meeting of the Institution of Mechanical Engineers, London, a paper was read in regard to the efficiency of marine engines and boilers by Prof. T. Hudson Beare.

The research committee on marine engine trials of this Institution has been for some time past engaged in making trials with different steam vessels. Six vessels have been experimented upon altogether since the committee was formed. These ships have consisted of channel passenger vessels and cargo boats, the committee not having had yet an opportunity of experimenting upon an important ship of the ocean liner type.

The labors of the committee have been brought to a conclusion for the present at any rate; and the paper of Prof. Hudson Beare was intended to give a summary of the results and afford a basis of discussion thereupon. We are at a loss, says *Nature*, how to condense within the compass of space at our disposal the mass of data dealt with by the author of the paper. Perhaps the most lasting impression on one's mind, after going through the subject, is that no general conclusions that can be compactly expressed are to be drawn from the trials. The conditions of work required from marine engines in ships of different classes are so various that what is paramount virtue in one case becomes an unnecessary refinement in another. Thus in the cargo boats the first consideration is economy in fuel, to which nearly every other feature in the machinery is usually sacrificed. In order to carry cargo at a rate sufficiently low to enable the shipowner to compete, the coal bill must be light, and therefore we find in these vessels boilers lightly worked and speeds low. On the other hand, vessels that have to convey passengers must be speedy, and general economy has to be sacrificed to this end, the model of the vessels themselves being formed with the same purpose in view. Perhaps we cannot do better than quote some of the elements of design of the machinery and some of the results attained during the trials, in order to illustrate these leading facts.

We will take two of the ships tried—the Iona, a large cargo boat, and the Ville de Douvres, a paddle boat carrying mails and passengers between Dover and Ostend. The Iona is 275 ft. long, 37·3 ft. wide, 27 ft. 7½ in. draught and 4,430 tons displacement. Her speed

on trial was 8·6 knots. The Ville de Douvres is 271 ft. long, 29 ft. wide, 9 ft. draught and 1,090 tons displacement. On her trial she made 17·1 knots. It will be seen, therefore, that the cargo boat is considerably over four times the displacement, and travels at about one-half the speed of the mail boat. As both craft are approximately the same length, the additional size and weight-carrying capacity of the Iona is made up by her greater beam and also by her fuller ends. The engines of the Iona are of the three stage compound, popularly but erroneously known as triple expansion engines. As a matter of fact, the Iona's engines are 19 expansion, the steam being expanded nineteen times in passing through the three cylinders. The Ville de Douvres has ordinary two cylinder compound engines, in which the steam is expanded but 5 7 times. The horse power required to drive the 4,430 tons of the bluff-ended Iona through the water was but 645·4 indicated, while the Ville de Douvres, modeled for speed, required 2,977 indicated horse power to enable her to get her 17 knots. Supposing each unit of power to be obtained in both ships at an equal expenditure of fuel, the figures quoted will show the price that has to be paid for speed; but there is a further item to the debit side of the coal bill in the case of the fast ship. In order to get high speed it is very desirable, indeed necessary, that machinery should be light, and light machinery, other things being equal, means a low figure of merit in regard to fuel economy.

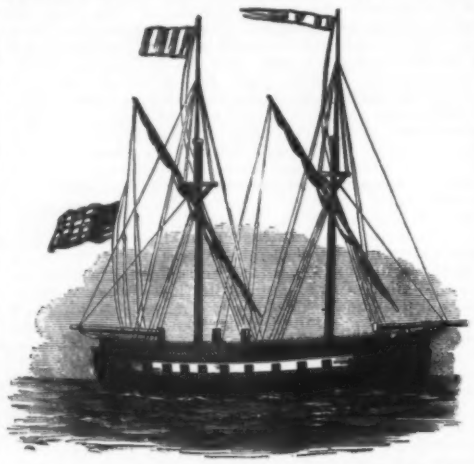
The Iona works, as stated, with 19 expansions, her boiler pressure being 165 lb. above atmosphere; while the Ville de Douvres has boilers pressed only to 105 lb. The result of this greater expansion of steam on the part of the cargo boat's engines and the easy way in which her boilers are worked enables each unit of power to be obtained on a consumption of 1·46 lb. of coal per hour; while the Ville de Douvres required 2·32 lb. of coal for each indicated horse power exerted for an hour.

It is easy to see from these figures, which are fairly representative, that economy and speed cannot go hand in hand; the owner must select whether he would rather travel cheaply (in fuel) or quickly.

Pursuing the investigation of this branch of the subject, we find that the total weight of the machinery of the Iona is 202 tons, which gives 3·1 units of power per ton weight of machinery; while the total weight of the machinery of the Ville de Douvres was 361 tons, equal to 8·2 units of power per ton weight of machinery. With regard to space occupied, the engines of the two ships are not comparable, being paddle and screw engines respectively; but in boilers we find that the net volume required for each indicated horse power with the Iona was 4·15 cubic feet, and with the Ville de Douvres 2·09 cubic feet, thus showing that space, as well as weight, may be gained by the sacrifice of fuel economy. In the discussion which followed the reading of the paper, Mr. Jeremiah Head, of Middlesborough, gave some interesting figures in regard to those cargo steamers generally known as "ocean tramps."

He stated that the steamship Westoe, a vessel of this class, had carried 3,500 tons dead weight at a speed of 9 knots, the fuel burned being at the rate of 0·64 oz. per ton per nautical mile, or about one five-hundredth of a penny. Another ship, the Oscar II., of 4,600 tons dead weight capacity, required a consumption of half an ounce of coal per ton per mile. Still another vessel steaming at 8·9 knots showed a similar fuel economy. The figures are striking and easily remembered: half an ounce of coal for each ton carried one nautical mile.

The boilers of both the Iona and the Ville de Douvres are of a similar type, being the ordinary return tube marine boiler, but the proportions are somewhat different. Thus in the Iona the proportion of total heating surface to grate surface is 75·2 per cent.; in the Ville de Douvres it is but 31·1 per cent. This large extension of the heating surface means both a heavier and more bulky boiler, as has been shown; but in the cargo boat this sacrifice of weight and space can be profitably made in order that the fullest amount of heat from the products of combustion may be absorbed by the water in the boiler. In the Ville de Douvres this heat is allowed to pass off by the chimney. If we turn to the record of funnel temperatures, we find this fact borne out, the escaping gases in the Iona being 452° Fah. and in the Ville de Douvres 910° Fah., as far as could be ascertained. The coal consumed on a given area of grate in the two vessels does not vary greatly, it being 22·4 lb. per hour in the Iona and 31·3 lb per hour in the Ville de Douvres. The different proportions of grate to heating surface in the two ships will, however, be remembered. If we turn to the coal burned per hour per square foot of heating surface, we find it but 0·298 lb. in the Iona and 1·01 lb. in the Ville de Douvres.



THE WAR STEAMER FULTON THE FIRST.

With regard to evaporation, each square foot of heating surface in the Iona's boilers turned 2·73 lb. of water into steam per hour; in the Ville de Douvres the corresponding figure was 9·02. The feed water evaporated per lb. of fuel was 9·15 lb. in the Iona and 8·97 lb. in the Ville de Douvres. Taking carbon values—that is, excluding incombustible ash—and reducing the results to an equivalent of evaporation from and at 212°, we find the corresponding figures to be 10·42 lb. for the Iona and 9·94 lb. for the Ville de Douvres, a by no means bad result for the latter vessel's boilers, considering the demand made upon them in other respects.

Turning to the engines of these two ships, we find that the efficiency of the Iona's engines was 17·1 per cent., while the Ville de Douvres' engines had an efficiency of 11·7 per cent. The weight of steam used in the main engines of the former vessel was 13·35 lb. per indicated horse power per hour, while in the Ville de Douvres there were required 20·77 lb. of steam to produce one unit of power.

The figures we have quoted will be sufficient to give an idea of the scope of the paper. We have not space to go into the discussion upon the various causes of the variations in results; for these we must refer our readers to the proceedings of the Institution, where also will be found an account of the long and interesting discussion which followed the reading of the paper.

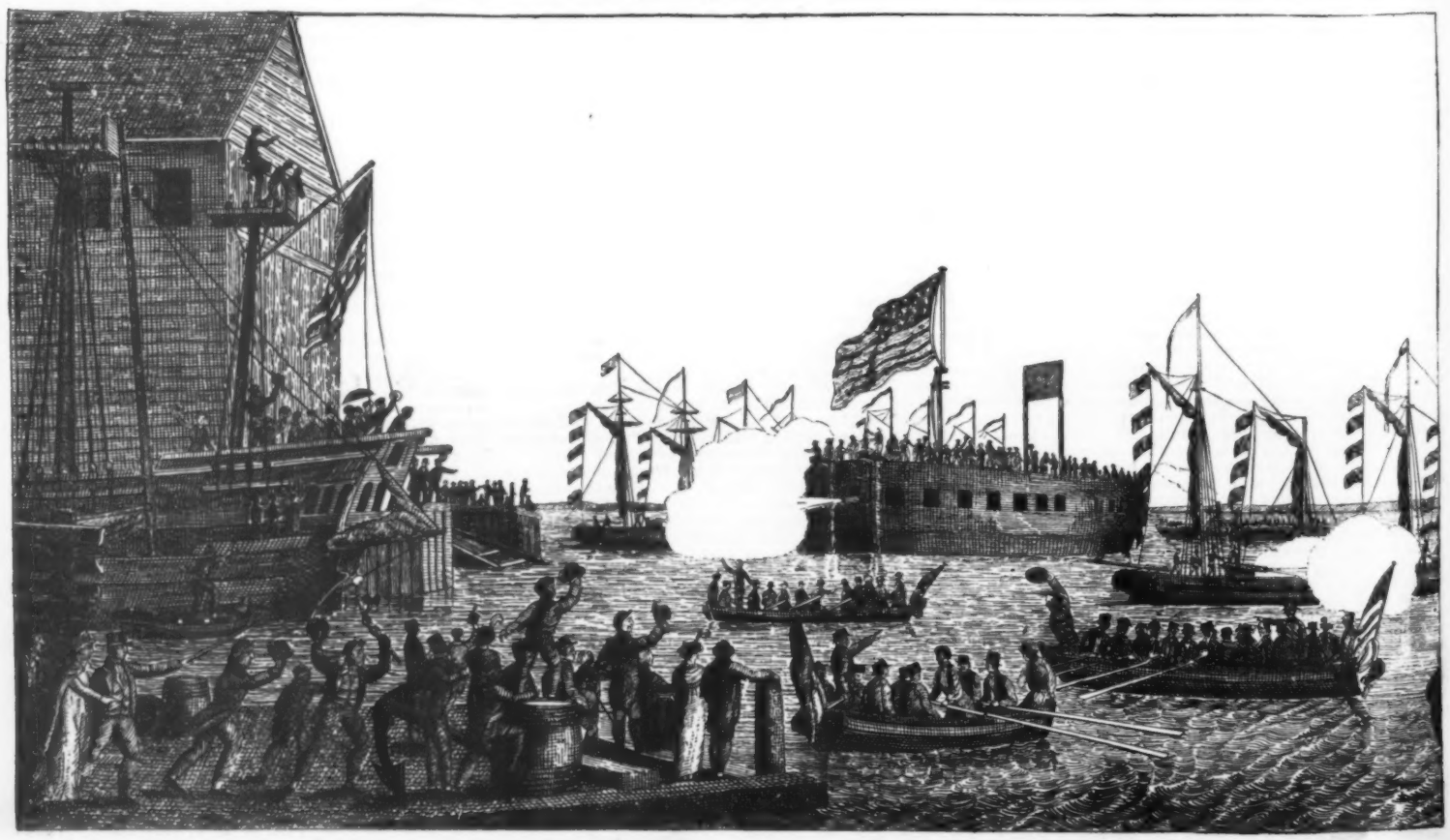
THE FIRST WAR STEAMER OF THE WORLD.

ROBERT FULTON, illustrious from his connection with the early invention of steam navigation, was not content to apply his inventive and constructive genius to passenger ships alone. During the war of 1812, when our navy was making a glorious record at sea, its disproportion to the work which it had to do in protecting the great line of coast was evident. For the defense of cities and harbors, Fulton designed a steamship of war, which he called the Demologos, the first war steamer of which there is any record. Fulton's original design for the Demologos presents a double-ended ship with two keels, flat bottom, and with a gun deck and main deck. Her sides were to be 5 ft. in thickness, diminishing below the water. In her center was a well containing a paddle wheel designed for her propulsion. A single cylinder engine was to be provided to turn the shaft; the weight of the engine on one side was counterbalanced by the weight of the boiler on the other. Twenty guns were to be carried by this craft. Her length was to be 140 ft., width 42 ft. The engraving opposite represents the original sketch submitted by Robert Fulton to the President of the United States. Fulton intended it to carry a strong battery, with furnaces for red hot shot, and to be propelled by steam alone at the rate of four miles an hour. It was proposed to have submarine guns suspended from each bow to attack a ship below the water line. An engine was to have been added to discharge hot water upon the enemy to repel boarders.

By special legislation a law was passed in 1812 authorizing the construction at New York of one or more floating batteries of this description. A sub-committee of three gentlemen obtained recognition by the government as agents for the construction of the ship: Samuel L. Mitchell, Thomas Morris, and Henry Rutgers—three good New York names.

The work of construction was carried out under the direction of Fulton as engineer, and Messrs. Adam and Noah Brown, of this city, as the naval constructors. Her keels were laid in the shipyard at Corlaers Hook, on the East River, New York, on June 20, 1814, and on the 29th of the following October she was launched in the presence of many spectators. She was named the Fulton the First. We give below a view of the launch, as drawn on the spot by the artist Morgan.

Our sketch of the launch shows her safely embarked in the water, firing her bow guns, while in the distance the low shores of Long Island are visible, not showing a single house where now is the great city comprising the Eastern District of Brooklyn. As launched, she was considerably modified from the original plans. She was 156 ft. long, 20 ft. deep, and 56 ft. broad. Instead of a small well for the paddle wheel, a long channel, 15 ft. wide and 66 ft. long, was provided for it. On one side of the hull was a copper boiler, 22 ft. long, 8 ft. deep, and 12 ft. wide. On the other side was the engine with one cylinder, 48 in. in diameter and 5 ft. stroke. The paddle wheel was 16 ft. in diameter and 14 ft. wide, giving a clearance of 6 in. from the sides of the channel. It dipped 4 ft. Her tonnage was computed at 2,475 tons—a very large vessel for that period. Her hull was designed by Samuel Humphreys, of New York, and cost $144,949. The boilers and engines were designed by C. W. Copeland. The engine cost $40,199 and the boiler $93,396. Great difficulty was experienced by the commissioners in getting men to work on her. It was war times. Many of the New York shipbuilders were gone up the lakes. Material was



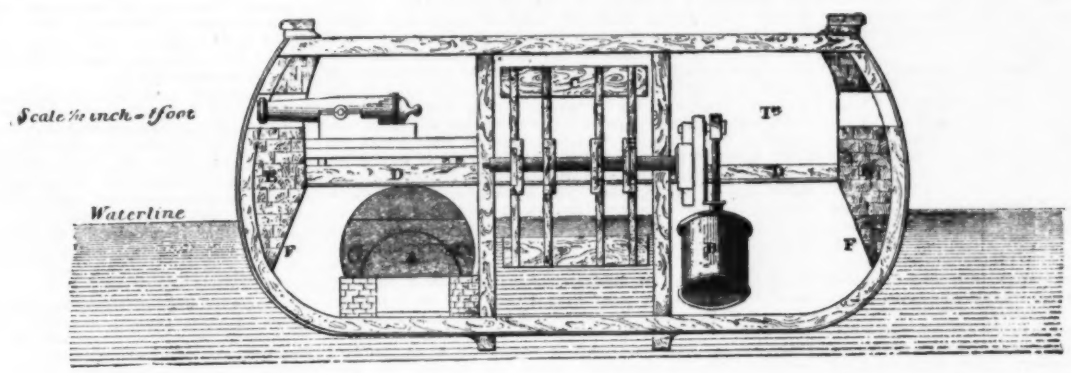
LAUNCH OF THE FIRST WAR STEAMER, THE FULTON FIRST, AT NEW YORK, OCTOBER 29, 1814.

very difficult to supply; guns were transported by land from Philadelphia, over the "miry roads of New Jersey," as the commissioners described them. Twenty heavy cannon were thus brought to New York. As completed she was to carry thirty long 32-pounders and two Columbiad 100-pounders. In the daily papers of these times are found a few notices of the progress of matters. Captain David Porter expresses, in 1814, the highest ideas of her capacity. He expects her to draw no more than 10 ft. with all her machinery, guns, and crew on board.

In the New York *Evening Post* of October 14, 1814, it is announced that "the Albany steamboat will postpone its trip to Albany until the Sunday following the launch." "The steamboat Williamsburg," it is announced, in the *Post* of October 28, 1814, "will accommodate such persons as may apply at the foot of Delancey Street." Finally, in the *Evening Post* of October 29, we find that "the Fulton the First was tri-

"DEMOLOGOS"

Figure I[a] *Transverse section* A *her Boiler*, B *the steam Engine* C *the water-wheel*, E E *her wooden walls 5 feet thick, diminishing to below the waterline as at* F F, *draught of water 9 feet* D D *her gun deck*



Scale ½ inch = 1 foot

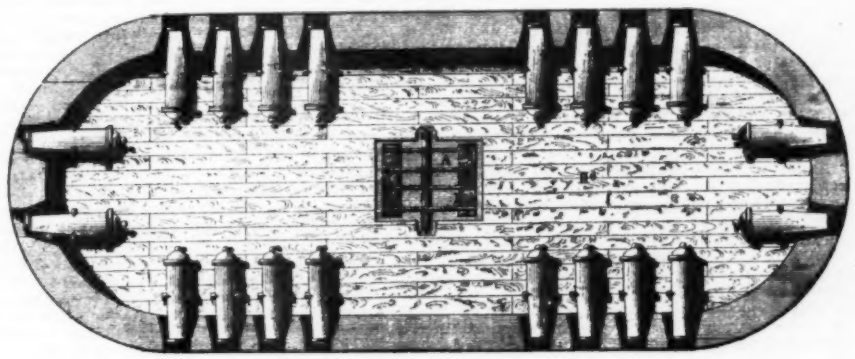
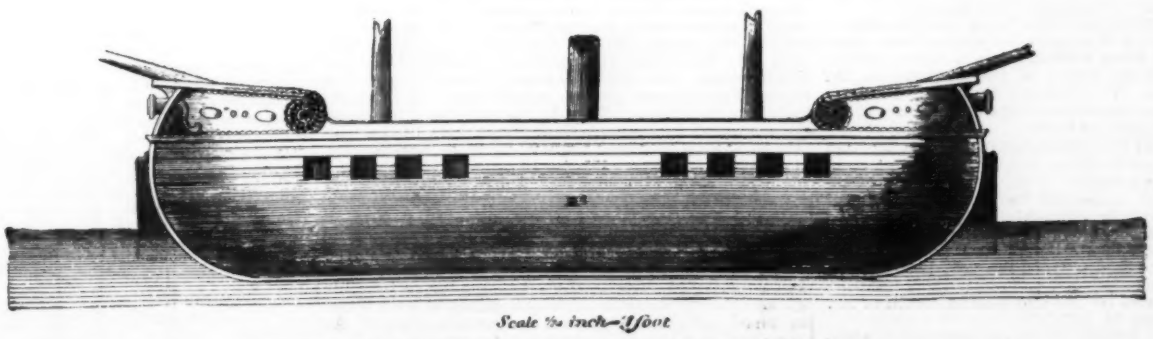


Figure II[a] *This shews her gun deck, 140 feet long 24 feet wide, mounting 20 guns* A *the Water wheel*

Figure III[a]
Side View



Scale ½ inch = 1 foot

THE WAR STEAMER FULTON THE FIRST.

umphantly launched amid the roar of cannon and the shouts and acclamations of upward of 20,000 people." A 32-pounder was discharged from her deck to give warning to the people. The jar of this discharge started her down the ways a quarter of an hour ahead of time. Her subsequent career was uneventful until the end came. In June, 1815, her engine was in a condition to try her, and on the first of the month at 10 o'clock, she went down New York Bay to the Narrows, on her first trial trip. On the Fourth of July of the same year she made a 53 mile passage out on the ocean and back in 8 hours and 20 minutes, and in September she made another trial trip, going against a three mile tide at the rate of 2½ miles per hour.

The war terminating, she was moored on the flats abreast of the Navy Yard, in Brooklyn, where she was used as a receiving ship. On June 4, 1829, about 2:30 P. M., she blew up; 24 men and a woman were reported killed, 19 wounded, and 5 missing. But a few minutes before the explosion, Commodore Isaac Chauncey, commandant of the Navy Yard, had been on board her. While in his office he heard the explosion, which seemed to him no louder than a 30-pounder. Owing to her very decayed state she was blown to pieces, although there were not more than 2½ barrels of damaged powder on board. There is no question that if she had been used in the war she would have proved a very formidable ship for those days, and would have done execution as great in degree as that done during her brief career in the civil war by the famous Merrimac.

We give a small engraving representing the appearance of the Fulton the First when finished and rigged. For this cut we are indebted to the publishers of the Memorial History of the City of New York, edited by James Grant Wilson. No description is given of the vessel, nor is any reference made as to the source from which the picture was derived. We have not been able to find an authentic portrait of the vessel, except that taken on the day of her launch by Morgan.

We give a copy of the original drawings of the ship as prepared by Fulton, which we take from the "Naval and Mail Steamers of the United States," by Charles B. Stuart, published in 1853. The name proposed by Fulton for his novel craft was Demologos, a term derived from the Greek and signifying "Voice of the People."

THE FIRST WAR STEAMBOAT.*

NEAR the close of the year 1813 Robert Fulton exhibited to the President of the United States the drawing of a proposed war steamer or floating battery, named by him the Demologos.

He contemplated, in addition to the proposed armament on deck, she should be furnished with four submarine guns, two suspended at each bow, to discharge a hundred pound ball into an enemy ten or twelve feet below her water line, and that she should have an engine for throwing an immense column of hot water upon the decks or through the ports of an opponent. Her estimated cost was three hundred and twenty thousand dollars, which was about the cost of a first class sailing frigate.

Fulton's project was favorably received, and in March, 1814, a law authorized the President to cause to be equipped "one or more floating batteries for the defense of the waters of the United States."

The construction of the vessel was committed by the "Coast and Harbor Defense Association" to a subcommittee of five gentlemen, appointed by William Jones, Secretary of the Navy.

Robert Fulton, whose soul animated the enterprise, was appointed the engineer, and on June 20, 1814, the *keels* of this novel steamer were laid at the ship yard of Adam & Noah Brown, in the city of New York. The blockade of our coast by the enemy enhanced the price of timber, and rendered the importation of copper, lead and iron, and the supply of coal from Richmond and Liverpool difficult; these obstacles were, however, surmounted, and the enemy's blockade only increased the expense of her construction. With respect to mechanics and laborers there was also difficulty: shipwrights had repaired to the lakes in such numbers that comparatively but few were left on the seaboard; besides, a large number had enlisted as soldiers. By an increase of wages, however, a sufficient number of laborers were obtained; and the vessel was launched on October 29, 1814, amid the hurrahs of assembled thousands.

The river and bay were filled with steamers and vessels of war in compliment of the occasion. In the midst of these was the floating mass of the Demologos, or Fulton, as she was afterward named, whose

* From a paper in the *United Service Magazine* on the "Origin and Development of Steam Navigation," by the late George H. Preble, Rear Admiral, U.S.N.

bulk and unwieldly form seemed to render her as unfit for motion as the land batteries which were saluting her.*

Captain David Porter, writing the Secretary of the Navy under date New York, October 18, 1814, says: "I have the pleasure to inform you that the Fulton the First was this morning safely launched. No one has yet ventured to suggest any improvement that could be made in the vessel, and, *to use the words of the projector, 'I would not alter her if it were in my power to do so.'*

"She promises fair to meet our most sanguine expectations, and I do not despair in being able to navigate in her from one extreme of the coast to the other. Her buoyancy astonishes every one. She now draws only eight feet three inches of water, and her draught will be *ten* feet with all her guns, machinery, stores, and crew on board. The ease with which she can now be towed by a single steamboat renders it certain that her velocity will be sufficiently great to answer every purpose, and the manner it is intended to secure her machinery from the gunner's shot leaves no apprehension for its safety. I shall use every exertion to prepare her for immediate service. Her guns will soon be mounted, and I am assured by Mr. Fulton that her machinery will be in operation in about six weeks."

On November 21, 1814, the Fulton was moved from the wharf of Messrs. Brown, on the East River, to the works of Robert Fulton, on the North River, to receive her machinery. The steamboat Car of Neptune made fast to her port and the Fulton to her starboard side, towed her to her destination at the rate of three and a half to four miles per hour.†

The dimensions of this, the *first war steamer*, were: Length, 150 feet; breadth, 56 feet; depth, 20 feet; water wheel, 16 feet diameter; length of bucket, 14 feet; dip, 4 feet; engine, 48 inch cylinder, 5 feet stroke; boiler, length 22 feet, breadth 12 feet and depth 8 feet. Tonnage, 2,475. She was the largest steamer by many hundreds of tons that had been built at the date of her launch.

The commissioners appointed to examine her in their report say: "She is a structure resting upon two boats, keels separated from end to end by a canal fifteen feet wide and sixty-six feet long. One boat contains the caldrons of copper to prepare her steam. The vast cylinder of iron, with its piston, levers and wheels, occupies a part of its fellow; the great water wheel revolves in the space between them; the main or gun deck supporting her armament is protected by a bulwark *four feet ten inches thick, of solid timber*. This is pierced by thirty port holes, to enable as many 32 pounders to fire red hot balls; her upper or spar deck, upon which several thousand men might parade, is encompassed by a bulwark which affords safe quarters. She is rigged with two short masts, each of which supports a large lateen yard and sails. She has two bowsprits and jibs and four rudders, two at each extremity of the boat; so that she can be steered with either end foremost. Her machinery is calculated for the addition of an engine which will discharge an immense column of water, which it is intended to throw upon the decks and all through the ports of an enemy. If, in addition to all this, we suppose her to be furnished according to Mr. Fulton's intention, with 100 pounder columbiads, two suspended from each bow, so as to discharge a ball of that size into an enemy's ship ten or twelve feet below the water line, it must be allowed that she has the appearance at least of being the most formidable engine of warfare that human ingenuity has contrived."

Such is a correct description of this sea monster of 1814, but exaggerated and fabulous accounts of her got into circulation. Among others, the following was published in a Scotch newspaper, the writer stating that "he had taken great care to procure full and accurate information."‡

"Her length," he writes, "on deck is *three hundred feet;* thickness of sides, *thirteen feet*, of alternate oak plank and cork wood; carries 44 guns, four of which are one hundred pounders; and further to annoy an enemy attempting to board can discharge one hundred gallons of boiling water in a minute, and by mechanism brandishes *three hundred cutlasses* with the utmost regularity over the gunwales; works also an equal number of heavy iron pikes of great length, darting them from her sides with prodigious force, and withdrawing them every quarter of a minute."

The stores of artillery at New York not furnishing the number and kind of cannon she was to carry, guns were transported from Philadelphia, a prize having placed some excellent pieces at the disposal of the Navy Department. To avoid the danger of their capture, twenty of these guns were sent over the miry roads of New Jersey dragged by horses.

In consequence of the exhaustion of the treasury and temporary depression of the public credit, the commissioners were instructed to pay the bills for the Fulton in treasury notes, but solely at par. These notes were often so long withheld that those who had advanced materials and labor were importunate for payment, and the commissioners had frequently to pledge their private credit. Once the men discontinued work. From these causes her completion was retarded until winter, and also by the unexpected death of Mr. Fulton, on February 24, 1815.

All difficulties at length being surmounted, the machinery was put in motion, and she made her first trial trip on June 1, 1815, only nine months after her keels were laid. On this trial she was found capable of opposing the wind, of stemming the tide, of crossing currents, and of being steered among vessels riding at anchor, though the weather was boisterous and the water rough. Her performance demonstrated the success of Fulton's idea, and that a floating battery composed of heavy artillery could be moved by steam.

She left the wharf near the Brooklyn ferry, propelled by steam alone, against a stiff south breeze (which was directly ahead) and a strong ebb tide, and steamed by the forts, saluting them with her guns, her speed equaling the most sanguine expectations.

After circumnavigating the bay and receiving a visit from the officers of a French ship of war, she came to anchor at Powles' Hook ferry about 2 P. M., nothing occurring to mar the pleasure or success of the trip. It was discovered, however, that alterations were necessary, some errors to be corrected, and some defects to be supplied, before she was prepared for a second trial.

On July 4, 1815, she again made a trip to the ocean, eastward of Sandy Hook, and back again, a distance of fifty-three miles, in eight hours and twenty minutes, without the aid of sails, the wind and tide being partly favorable and partly against her, the balance rather in her favor. The gentlemen who witnessed this experiment without exception entertained no doubt as to her fitness for the intended purpose. Expedients were sought to increase her power, and devised and executed for quickening and directing her movements.

A third trial of her powers was attempted, on September 11, with twenty-six of her long and ponderous guns and a considerable quantity of ammunition and stores on board. Her draught of water was less than eleven feet. She changed her course by reversing the motion of her wheels, without the necessity of putting about, like the ferry boats of the present day. She saluted as she passed the forts, overcame the resistance of the wind and tide in her progress down the bay, and performed beautiful maneuvers around the United States ship Java, then at anchor near the lighthouse. She moved with remarkable celerity, and was perfectly obedient to her double helm. The explosion of powder produced very little concussion on board, and her machinery was not affected by it in the slightest degree. Her progress during the firing was steady and uninterrupted. On the most accurate calculation, her velocity was four and a half miles an hour, and she made headway at the rate of two miles an hour against the ebb of the East River, running three and a half knots. The day's exercise was satisfactory to the company on board beyond their most sanguine expectation, and it was universally conceded that the United States possessed a new auxiliary against every maritime invader. The city of New York was considered as having the means of making itself invulnerable, and that every bay and harbor of the nation might be protected by the same tremendous power. Her performance more than equaled Fulton's expectations, and it exceeded what he had promised the government—that she should be propelled by steam at the rate of from three to four miles an hour.

The commissioners who superintended her construction congratulated the government and the nation on the event of this noble project, and said: "Honorable alike to its author and its patrons, it constitutes an era in warfare and the arts. The arrival of peace indeed has disappointed the expectations of conducting her to battle. That best and conclusive act of showing her superiority in combat has not been in the power of the commissioners to make.

"If a continuance of tranquillity should be our lot, and this steam vessel of war be not required for the public defense, the nation may rejoice in the fact we have ascertained as of incalculably greater value than the expenditures, and that if the present structure should perish, we have the information, never to perish, how, in any future emergency, others may be built. The requisite variation will be directed by circumstances."

The war having terminated, Fulton the First, after these trial trips, was taken to the navy yard at Brooklyn and moored on the flats abreast of that station, where she was used as a receiving ship until June 4, 1829, fifteen years after the laying of her keels, when she was accidentally or purposely blown up.

Commodore Chauncey, reporting this catastrophe, says that he had been on board of her all the morning inspecting the ship and men, particularly the invalids, who had increased considerably from other ships, and whom he had intended asking the department's permission to discharge, as of little use to the service. He had left the ship but a few moments before the explosion took place. The report did not appear to him louder than a 32 pounder, although the destruction of the ship was complete and entire, owing to her very decayed state. There was on board at the time no more than two and a half barrels of damaged powder, kept in the magazine, for the morning and evening gun. By this explosion, however, twenty-four men and a woman were killed, nineteen wounded, and five reported as missing and probably killed. Among the killed was Lieutenant S. M. Breckinbridge, and among the wounded Lieutenant C. F. Platt, who died a captain in the navy, Lieutenant A. M. Mull, and Sailing Master Clough; Lieutenant Platt was dangerously, the others severely, wounded. Four midshipmen were among the wounded.

Commodore Chauncey was of opinion that "the explosion could not have taken place from accident, as the magazine was as well or better secured than the magazines of most of our ships; yet it is difficult to assign a motive to those in the magazine for so horrible an act as voluntarily to destroy themselves and those on board, yet if the explosion was not the effect of design, I am at a loss to account for the catastrophe."

Master Commandant John T. Newton,* her commander, was on shore at the time of the explosion. Such was the beginning, end, and uneventful history of the first steam vessel of war ever put afloat—the pioneer, and to an extent the model also, of the floating batteries, double-hulled vessels, and "double-enders" which have succeeded her.

Captain E. C. Bowery, U. S. N., a surviving officer of the Fulton, writing me under date December 13, 1881, says: "I say the destruction of the Fulton was by carelessness. I believe in Divine Providence, but not in accident. I joined her in the early part of 1826 as an acting midshipman, Commander Budd then having command. Her magazine (if it could be called one) was nearly under the ship's coppers, and separated only by a light bulkhead was the 'bag room,' in which the sergeant of marines had a writing desk, on which was a naked oil lamp. Soon after reporting, I had occasion to go down there; the bulkhead had a sliding door, which was open, and his lamp shone on the kegs of powder, one of which was without a head. I remarked to the sergeant, 'If your light was only five feet nearer (all the space that separated it from the powder) there would be trouble.' 'Yis,' said he, turning his beery eyes on me, 'there would be a sensation.' After that I never turned in at night without thinking there might be a sensation before cock crowing, and to this day I have not forgot the appearance of that powder with the light shining on it, and draw the inference that gross carelessness caused the sensation. Yet at the time there was a story that a gunner's mate had been disrated and punished with the cats the morning before the blowing up of the Fulton."

GEORGE H. PREBLE,
Rear Admiral, U.S.N.

(To be continued.)

* I have seen a large copper plate engraving of the launch of the Fulton. It is entitled "Launch of the Steam Frigate Fulton the First, at New York, Oct. 29, 1814; one hundred and fifty feet long, fifty-seven feet wide, mounting thirty long 32 pounders and two 100 pounders (columbiads). Philadelphia: published March 27, 1815, by B. Tanner, 74 South Street. Drawn by I. I. Baralet, from a sketch by Morgan, taken on the spot."

† "Rees' Encyclopedia" states she was towed on this occasion by the Paragon, of three hundred and thirty-one tons burden, at the rate of four miles an hour. That she was towed by Car of Neptune and Fulton is, I believe, correct.

‡ Stuart's "War and Mail Steamers" has accurate drawings of the Fulton from the originals.

* Captain Newton also commanded the Missouri when she was burned in Gibraltar Bay, 1844.

THE NAME OF ROBERT FULTON FOR A WAR STEAMER.

WE elsewhere illustrate and describe a famous war ship, the Fulton the First, built in 1814. With her sides impenetrable by the artillery of those days, with her machinery and boilers in great part below the water line, and her paddle wheel in her center, she was in those days an almost invincible craft. It is on record that she excited the apprehensions of the British government, the most extraordinary qualities of destructiveness being attributed to her. As it happened, she never had a chance to figure in war, the treaty of Ghent and its results being communicated about the time of her completion.

She appears as the first steam man-of-war ever built. She is really the corner stone of the navy to-day, and in her Fulton may be said to hold an undisputed priority. It seems fitting that this country should in some way acknowledge his work. In the English navy, the names of ships are hereditary. After one ship has passed out of service, a second one, naturally of improved construction, will be built, and to her will be awarded the name of her predecessor. In this way, one after the other, a long and honorable lineage under the identical name may be established. After the destruction of the Fulton the First our navy made a second essay in the construction of a war steamer, and in 1837 and 1838 a ship was built, propelled by steam and fitted with sails, which was termed the Fulton the Second. She was provided with protective wooden bulwarks, beveled as far as possible to cause the enemy's shot to glance off. Although she made a trip to the West Indies and back, she was not designed nor suited for use in ocean work. The well known Charles H. Haswell was her chief engineer. Subsequently, in 1851, this ship was rebuilt and was termed the Fulton the Third.

In our present steam navy Robert Fulton should receive due commemoration as its founder. His name should be given to our most advanced ship, and it should be understood that hereafter, as such ship would pass out of service or would fall from the first rank, the name should pass to the best ship in the navy.

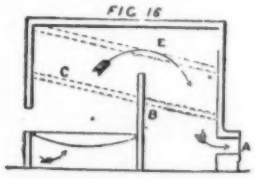
[Continued from SUPPLEMENT, No. 954, page 15246.]

WATER TUBE BOILERS.*

IT matters nothing how well arranged a tubulous boiler may be in the way of providing for circulation of the water and the supply of dry steam, it cannot give satisfaction unless it is properly heated. Now, it is in some senses unfortunate that the water tube boiler may be heated not in one way but in many; while the fire tube boiler can really be heated in only one way. Take, for example, a locomotive boiler. The furnace is a box, the sides and roof of which are admirably situated for taking up radiant heat, while the products of combustion can only find their way by one route to the chimney. But the tubulous boiler has no fire box, and no special route definitely marked out for the escape of the products of combustion; and this circumstance goes far, we think, to account for the great diversity of results obtained in practice with water tube boilers. It is, then, of the utmost importance that correct views should be held on the subject. We, however, can do no more than put a few general facts and principles before our readers, who must learn to apply them in each case as can best be done.

It is very frequently assumed that if heat is generated it is of little or no importance how it is applied, the result must be the same. Theory justifies the assertion, practice flatly contradicts it. The theory is obviously erroneous. To put the matter in a more precise form, let us assume that we have a brick oven built, 10 ft. long, 5 ft. wide, and 10 ft. high. At one end is a grate, 5 ft. long and 4 ft. wide; at the end of this grate is a brick wall, 5 ft. high. The delivery to the chimney is at the same level as the grate, 4 ft. long and, say, 9 in. high. The sketch, Fig. 16, will make

FIG. 16



our meaning clear at a glance. It is evident that when a fire is lighted in the grate, the products of combustion will escape in the way of the arrows. It is taken for granted that it matters nothing how a water tube boiler is disposed within this oven, the economical and other results must be the same.

The heat is all produced inside the walls, and it cannot get out save through A. The walls are supposed to be sufficiently thick and well fitted with air spaces to prevent the escape of heat to any extent through them. Let us suppose now that we have a water tube in the position shown by the dotted line. We shall find that in practice, although that half of its length marked B is within the oven, yet as a steam generator it is almost useless, simply because the hot

* From the *Engineer*, London.

products of combustion beat down on the top of the tube. We need not stop to explain to our readers why it is that heat cannot, under such circumstances, be communicated to the pipe length, B. Again, as the hot gases will always take the shortest possible route to the chimney, they will have nothing to do with that part of the tube marked C. But there are more tubes than one. The top tube, E, is very much worse off, obviously; and by pursuing the investigation further, it will be found that the tubes are really not heated uniformly along their whole length, but only in belts or bands; and, furthermore, the radiant heat at the sides of the fire is lost. It is a mistake to assume that if it is not taken up by the tubes at once, it goes to raise the temperature of the gases. For some reason so far inexplicable, if radiant heat is not pounced upon and seized at once, it can never be got in any other form subsequently. A well known case was that of certain locomotives with very deep fire boxes which would not keep steam. The grates were raised about a foot, no other change being made, and then the radiant heat did its work on the roof and upper part of the sides of the box, and the engine steamed well. The loss of radiant heat in water tube boilers of the Root type has been so fully recognized that improvements have been effected; one firm places the furnace in a water casing, and another disposes pipes at its sides. Fig. 16*a* shows a water tube boiler with a water-cased

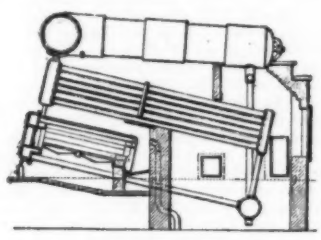
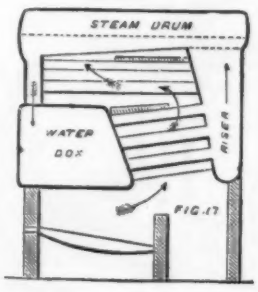


Fig. 16a

furnace. It may be of interest here to add that in an instance which came under our notice, not long since, a water tube boiler, which gave wet steam, was very uneconomical and very inefficient as well, was cured of all its faults by the simple expedient of raising the grate and making it a little longer and narrower.

It is often urged against the Root type that it is inefficient because it makes only three or four pounds of steam per square foot of heating surface per hour. This may mean anything or nothing. All that it goes to show, in our opinion, is that there is much useless surface provided. Taking Fig. 16, it seems to be pretty clear that the pipes at the chimney side of the bridge might be greatly shortened without doing any harm. The idea involved in making these pipes so long appears to be that in no other way can economy be secured. That this lengthening of the tubes does very little good is proved by two facts. First, the De Naeyer boiler—popular on the Continent—consists really of two boilers, one placed behind the other; No. 2 being really a heater or economizer more than a boiler. Secondly, economizers can always be added with much advantage to boilers of the Root type. Bearing in mind what we have already said about distribution, every one of our readers interested in the subject will understand how much may be done with the aid of tiles laid on tubes to distribute the gases; and it ought to be found possible in all cases to avoid the down draught and carry the smoke upward, so as always to apply the heat to the under sides of the tubes. Beyond question, much of the inefficiency of the water tube boiler is due to the way in which the heat is applied. But, on the other hand, it must not be forgotten that the engineer is not always free to do what he wishes. For example, a better result would be got in the case of Fig. 16 if the pipes were shortened in length by one-third, and the same surface maintained by adding to their number and arranging them in a greater number of vertical tiers, the products of combustion always ascending between them to the chimney. But a little thought will show that the arrangement might make the whole structure too high, and that by adding unduly to the number of tiers delivering into single headers, heavy priming might be set up for reasons already explained. Again, it is wrong in principle to apply the greatest heat at the highest end of the tube. As the bubbles of steam in rising drive or push the water before them, the circulation will be more assured if the bulk of the steam is made in the lower ends of the tubes. But to this plan there may be objections. Thus, for example, it might bring the grate too near the tubes, and the furnace door might interfere with the back header. The arrangement roughly sketched in Fig. 17 shows a method of



construction for which many advantages might be claimed. Here a water box is placed over the fire to catch the radiant heat, and the hot gases pass up through the tubes, so that there is no waste surface. The objections to the scheme will suggest themselves as freely as the advantages.

On one point it is necessary to insist—it is constantly overlooked or forgotten—it is that the hot gases ought always to be caused to beat against the surface to be heated, and not allowed to run along it. Thus the plate, A, is much more efficient than the plate, B. As a rule this principle can be very freely applied in water tube boilers. Thus, if we turn to Fig. 16, it will be seen that the gases move nearly at right angles to the tubes. In the case of the Yarrow boiler they do the same, the tubes being nearly vertical and the gases moving horizontally, or at least nearly at right angles to the tubes. But circumstances may arise when a better result can be got by allowing the gases to move as in B. Because, if a vertical tube be placed in a stream of gas moving in a horizontal direction, then one side only of the tube will be heated, as in Fig. 18, the zone

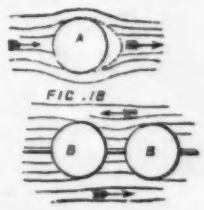


FIG. 18

marked by the dotted line being nearly free from hot gas. If one pipe stands between and shelters another, the case is, of course, still worse. If the pipes are arranged as at B B, and currents of hot gas pass as shown by the arrows, then the whole or nearly the whole of the tube surface may be regarded as efficient, and the principle can be applied in practice with very excellent effect, as we hope to show when dealing with the question of reduction of weight.

Summing up, we may say that the number of ways in which the heating surface of a tubulous boiler can be arranged is almost endless, and that in very many instances the wrong arrangement is adopted, sometimes through ignorance, sometimes because advantages are secured which countervail or are believed to countervail the loss. Thus, for example, the down draught system, Fig. 16, is extremely convenient when a battery of boilers have all to deliver the products of combustion into one culvert common to them all, leading to the chimney. This makes not only a very neat arrangement, but positively, in many cases, where the boilers are working in crowded cities, the only arrangement that is possible. Where, however, it is possible to avoid them, no down draughts should be permitted. They, in all cases, represent waste of heating surface at all events. Furthermore, every effort should be made to take up the radiant heat.

One matter of very great importance must be mentioned, although the ground it covers is too large to be entered upon here. Unless care is taken, tubulous boilers will produce clouds of smoke; indeed, none of them are adapted for the use of bituminous coal. We do not say that such coal cannot be burned; we do say that we have seen so much trouble incurred in the attempt to burn it that a word of warning is necessary to those who propose using it. Abroad the difficulty has been dealt with by the adoption of step grates; but the boilers fitted with these are not pushed hard. In this country mechanical stokers, especially Jukes' grates, have been used with success; but they will not tolerate much forcing. If bituminous coal must be used, the grates and boilers should be big enough to provide all the steam needed without hurrying them. If this is not done, then smokeless—or nearly smokeless—steam coal must be provided. It should never be forgotten that the success of the mechanical stokers in keeping down smoke depends mainly on their being worked a fixed pace, maintaining constantly the same thickness of fire; and the best rate, so far as the suppression of smoke is concerned, having been got by experiment, it must be steadily adhered to subsequently.

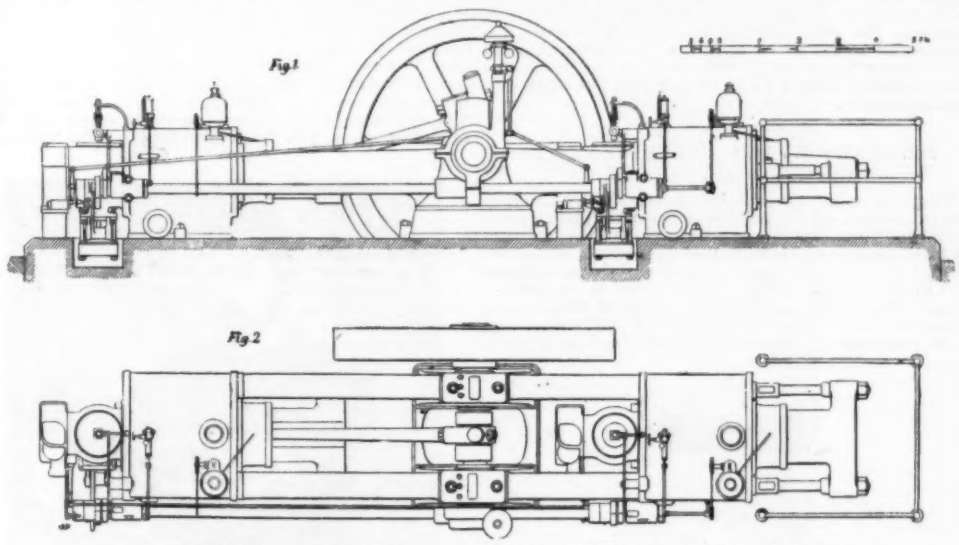
(To be continued.)

TWO HUNDRED HORSE POWER GAS ENGINE.

THE Fielding tandem gas engine illustrated below comprises a pair of cylinders arranged end on in one line, both pistons acting in the same direction, so as to impart an impulse at each revolution at equal intervals when working at full power. The pistons are connected to each other by steel tie rods passing beneath the crankshaft, the latter being kept above the cylinder center for this purpose, and also in order to reduce the angular thrust of the connecting rod during the acting strokes. In order to relieve the piston, to which the connecting rod is attached, from the angular thrust, planed guides are formed in the engine bed to receive guide blocks formed on the piston crosshead; this is an important feature in such large engines.

The cylinders are fitted with loose liners of hard cast iron, so arranged as to allow of their free expansion independent of the jacket. The pistons are packed by five hard cast iron Ramsbottom rings, a loose junk ring being fitted, with solid intermediate rings between each pair of piston rings. Special steel miter valves of extra large area are provided for gas and exhaust, all operated by separately adjustable cams. The governor is of the high speed rotating type driven by helical gearing. The speed can be varied while the engine is running. The main valve box is a separate casting from the cylinder jacket, secured by bolts and fitting into a bored recess in the jacket, an important feature being the avoidance of a large asbestos joint ring exposed to the heat and pressure of the explosion, as in other engines. Lubrication is attended to very carefully to enable continuous running day and night, for which these tandem engines are specially designed.

The system of self-starting used in connection with these large engines is most powerful, while it is both safe and sure in operation. By it an engine can be started against two-thirds of the load, and this without any undue shock, because it starts the engine slowly at first before the explosion takes place, so that all slack is taken up and the inertia overcome before



TWO HUNDRED HORSE POWER FIELDING TANDEM GAS ENGINE.

the acting charge is ignited. It is perfectly safe, as compressed air is stored at a pressure of about 60 pounds per square inch by the action of the piston in stopping, and is used in conjunction with an ordinary self-starting apparatus. No explosion takes place except within the cylinder, as in working; the operation is the simplest possible and quite certain. The makers of the engine are Messrs. Fielding & Platt, of Gloucester.—*Engineering.*

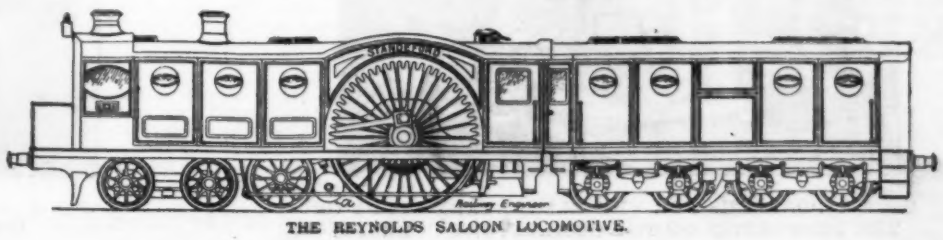
THE REYNOLDS SALOON LOCOMOTIVE.

THE annexed sketch, which is reproduced from the *Railway Engineer* (London), illustrates the general features of the engine about which such sensational paragraphs have been appearing in the daily press of England and to some extent copied in this country.

Mr. Reynolds was for many years a driver of the Scotch and Irish mail trains; he then went to the Brighton line, which he left when he was chief locomotive inspector, so that he has a good knowledge of the working of locomotives. In connection with the drawing from which the illustration was made, Mr. Reynolds writes as follows:

In designing the Standeford, I had in view an acceleration of speed, and the ultimate possibility of the engine being called upon to do a run of 500 to 1,000 miles without a stop.

Now, as to the question of safety. More than one critic pities the road; as if one would design an engine for 80 miles an hour without thinking of the road. But the Standeford is so constructed that I venture to pre-



THE REYNOLDS SALOON LOCOMOTIVE.

dict it will be a very steady runner—steadier than any express engine now working express traffic. In the first place it stands on a long, substantial wheel base, and has three bogie carriages under it. In the next place it has three crank pins on one axle, and these are placed at an angle of 120° apart, which is obviously most conducive to easy turning effort, and practically reduces the disturbing causes to a minimum. Lastly, the employment of a big wheel reduces dead center points per mile, which, not a little, contributes to easy running and steadiness. In a sentence, the means employed are commensurate with the ends to be attained.

The outside cylinders are 18 by 30 in., and the middle cylinder 14¾ by 30 in., which drive a 10 ft. wheel. The cylinders are steam jacketed. The jackets are between the outlet and inlet steam pipe to the injectors, an arrangement which secures a circulation of steam in the jackets and draws off the condensed water.

To prevent this driving wheel slipping, under any conditions or circumstances, there is fitted a steam coupler (*a*) between it and the intermediate wheel in front, which at starting a train partially turns the engine into a four wheeled coupled. It is at starting that the maximum tractive power is required. For high speed driving-wheels are best single. We have, then, in the Standeford two classes of engines rolled into one.

As showing the drift of my purpose, to secure a steady engine the steam is not admitted to the piston until the crank is about 12° over the center, and the piston on the return stroke is gradually cushioned by compressed steam.

The firebox tube plate would be a separate plate riveted on to the front plate of the firebox, and would enter the barrel about 8 inches. A water arch would be used, and tubes of Everitt's red metal. Boiler pressure 200 lb. The water tank has a capacity of 3,000 gals., and a "pick up" arrangement would be required. The bunker holds 3½ tons of coal. A crew of three men would be carried.

It will be seen that there would be no particular difficulty about building the engine; but as to utilizing it subsequently great difficulties would undoubtedly present themselves.

As regards speeds, Mr. Reynolds writes that he aims at an average high speed of 70 to 80 miles an hour, and longer runs without stopping, and what is now done down banks he wishes to have done on the level, and kept up. He considers that an engine built to his design would accomplish this task at a less cost than 50 miles an hour now costs. He estimates the consumption of coal at from 8 to 10 lb. per mile less than any modern engine.

DR. D'ARSONVAL'S EXPERIMENTS IN ELECTRO-PHYSIOLOGY.

THE new paths opened up to electric science through the production of oscillations of great frequency have permitted the industries as well as electro-therapeutics to enter upon domains hitherto unexplored. Dr. D'Arsonval, who is particularly prepared for researches of this kind through a series of inventions in electricity, has, in this direction, pursued a course of remarkable researches in electro-physiology for which the Academy of Sciences has just awarded him the La Caze prize.

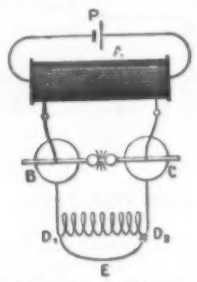


FIG. 1.—DIAGRAM OF THE APPARATUS REPRESENTED IN FIG. 2.

We shall leave the duty of treating the purely physiological part of the question to other hands, but it appears of interest to us to describe here certain extremely curious phenomena to which currents of very great frequency give rise, after briefly mentioning the apparatus that serve for obtaining them.

Dr. D'Arsonval's experiments constitute the counterpart of the remarkable ones of Mr. Tesla that are known to our readers. The latter have especially in view the production of light, while the former are important by reason of the new facts that they reveal to us upon the relation between the nerves and electricity. Mr. D'Arsonval's apparatus are simpler than those of Mr. Tesla; they are less pretentious, and produce less powerful effects, and have the advantage of being within the reach of all laboratories possessing a minimum of the apparatus classic in electricity.

Mr. D'Arsonval's first researches date from far back, and the question of physiological action of currents of

FIG. 4.—ILLUMINATION OF A LAMP BY INDUCTION UPON A RING OF WIRE.

all frequencies was solved in France long before the first publications of Mr. Tesla in America.

Production and Properties of Oscillatory Currents.—We know that, under certain conditions, an electric discharge becomes oscillatory. A very simple arrangement, the principle of which was borrowed by Mr. D'Arsonval from Mr. Lodge's experiments upon lightning rods, permits of producing this kind of discharges and of demonstrating an essential property of currents of great frequency. A Ruhmkorff coil, A (Fig. 1), serves to charge through their interior coatings two Leyden jars, B and C. The discharge that takes place between the opposite buttons is oscillatory. The potential of the external coatings varies with the same frequency, but the current, in a wire that connects them, varies more abruptly than in the circuit embracing the spark. If the external coatings be connected by a bobbin, D_1 D_2, formed of twelve spirals of coarse copper wire, they will have been put in short circuit for an ordinary current, and we could keep up a difference of a few volts between the coatings only by causing a current sufficient to volatilize it in a wink of the eye to pass into the wire. But here is wherein the oscillatory discharge shows its very peculiar character; it has an invincible repugnance to entering the wire. The reason of this is simple. The extremely rapid variation of potential that establishes itself at the terminals of the bobbin produces currents that vary with formidable rapidity, and are, consequently, possessed of enormous conductive power. The induction of each spiral acts upon the neighboring ones, and the resulting current tends at every instant to annul the primary one, so that but a feeble portion of the current passes. To calculate here the resistance, such as Ohm's law defines it, serves for nothing; we must compete with an entirely different antagonistic force combined with the resistance and induction, and which is called impedition. It is the sum of the *impedimenta* that the current finds upon its route. In the case that occupies us, the impedition is reduced practically to the force antagonizing the induction. How rebellious the oscillatory discharge is to entering the bobbin may be shown as follows: Applying a wire, E, to its extremity, D_1, and bringing it near the last spiral, D_2, there will be seen to start forth in the interval a gerb supplied with strong sparks and more than a centimeter in length (diagram and Fig. 2, details). The discharge, therefore, more easily traverses one centimeter of air than a resistance practically negligible, but possessing induction.

FIG. 5.—ILLUMINATION OF A LAMP BY THE CURRENTS INDUCED IN THE ARMS OF THE OPERATOR.

Physiological Actions.—What will happen if we touch the extremities of the bobbin? Apparently, we shall receive the entire discharge accompanied with so strong a shock that, after the example of one of the first electricians, we would not begin the experiment again for the kingdom of France. To our great surprise, we feel neither the shock nor even the slightest pricking sensation. Has the discharge changed direction again? In nowise; for if, instead of touching the bobbin at both ends, we content ourselves with bringing near one of them a piece of metal held in the hand, we shall see the sparks reappear. Furthermore, we can put an incandescent lamp in our circuit and see it become brilliantly lighted (Fig. 2). The current, then, really traverses our body without our suspecting it, thus showing another of its caprices. To what is its innocuousness due? The first idea that occurs to the mind is that the current passes entirely to the surface of the body, in the epidermis and in the clothes. In this explanation there is doubtless some truth, but such localization of the current is not the sole cause of its immunity. Mr. D'Arsonval's researches have shown that neuro-muscular phenomena increase in intensity with the frequency up to 3,000 alternations per second, remain sensibly stationary up to nearly 5,000 alternations and afterward decrease to become soon annulled. A frog's foot is insensible to the Hertz oscillator, as has been shown by Mr. Joubert. And yet the physiological action of these currents is far from being null. Its passage in the tissues is accompanied with singular effects: 1. If, for a certain time, the current be closed through the hands provided with wide metallic

FIG. 6.—LAMP LIGHTED IN THE HANDS OF AN OPERATOR INCLOSED WITHIN A SOLENOID.

FIG. 2.—APPARATUS FOR THE ELEMENTARY STUDY OF THE PROPERTIES OF THE OSCILLATORY CURRENT.

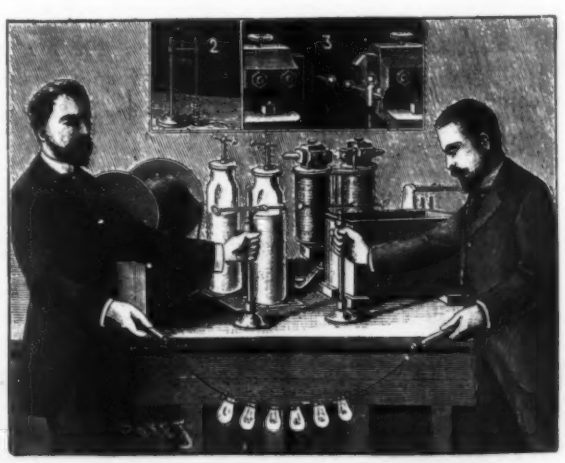


FIG. 3.—APPARATUS FOR THE PRODUCTION OF INTENSE OSCILLATORY CURRENTS.

conductors, we shall find that the skin has become insensible. This insensibility lasts from a few minutes to half an hour. 2. Under such conditions, and also upon insulating one's self upon a glass stool, and in taking but one pole, a sensation of heat is obtained soon accompanied with an abundant production of perspiration and with a considerable vascularization of the cutaneous surface. 3. Finally, if a small wound be made in the foot of an animal, so that the blood escapes from it drop by drop only, the hemorrhage will be seen to become very abundant under the influence of the current. There is then an energetic vaso-dilative action.

Therefore the current traverses the body, but the nerves have become insensible to such a frequency.

The few experiments we have just described may be made with the small apparatus that we spoke of in the beginning; but a more powerful installation permits of greatly increasing the effects, without, moreover, essentially modifying them. Fig. 3 shows the large apparatus, in which a transformer supplied by an alternating current dynamo is substituted for the bobbin. The discharge spark of the Leyden jars, instead of flashing forth in the free air, is produced in a powerful magnetic field. It then spreads out in a luminous circle and produces a deafening noise. We no longer light again as shown in the figure, a single lamp, but an entire series of lamps that the operators hold in the hand without a metallic communication with the apparatus.

It was in making allusion to this experiment that Mr. Cornu, at the session of the Academy of July 3, 1893, said: "It would be impossible to suspect the enormous quantity of electricity traversing our body; . . . transmitted under the form of alternating currents of long periods (from 100 to 10,000 per second), it would suffice to strike us down like a thunderbolt. Under the above conditions, it produces no appreciable sensation."

Autoconduction.—In all the experiments of which we have spoken, the oscillatory current engendered in a metallic circuit, was utilized either for its physiological effects or for its physical actions; but, as we have seen, this current possesses an enormous inductive power. Why, then, would it not produce induction directly in the living tissues? Every part of the body, or such a part as it is desired to treat, would thus become the seat of an electro-motive force and be so entirely, or one region only of the body would be uniformly penetrated by the currents that originate in the very midst of the tissues. This is what Mr. D'Arsonval demonstrates by means of the following experiments:

In Fig. 4 we see an operator carrying a brilliantly lighted lamp upon his forehead. This lamp, mounted upon a single turn of wire, is a few centimeters distant from a crown, with which it has no direct communication. This latter, traversed by the oscillatory discharge, develops in the ring a current sufficient to supply the lamp. Consequently, it is clear that the head itself is traversed by analogous currents.

The existence in the human body of currents produced by autoconduction may be rendered evident by a conclusive experiment. If the operator surrounds a solenoid (as shown in Fig. 5) with his arms, thus forming a circle completed by a lamp, whose terminals he holds in his hands, the lamp will be observed to become illuminated. An analogous phenomenon occurs when the patient is inclosed in a solenoid (Fig. 6).

The measurement of currents of great frequency naturally necessitates new processes. The one to which a chance experiment led Dr. D'Arsonval is not yet perfect, but it permits, at least, of registering the currents employed and of reproducing them at will. The currents induced in the interior of the conductors disengage heat, which is the measure of their energy. It will suffice, then, to cause the induction to act upon a mercurial thermometer and to note the elevation of its temperature in order to obtain an idea of the intensity of the inductive current, if its frequency varies but slightly.

At the top of Fig. 3 (No. 2) will be seen the arrangement of the experiment. The thermometer is placed in the axis of a small solenoid traversed by the oscillatory discharge. In an instant, it will be seen to rise by 150 or 200 degrees.

Currents of high frequency now give us so singular results that no one would have predicted them four or five years ago. Some engineers think that their industrial future is immense, and it would be very imprudent to assert the contrary. Their physiological actions are mysterious, and although Dr. D'Arsonval has had the merit of discovering some of them, it must not be forgotten that in this domain, which was untrodden but a few months ago, almost everything remains to be done. The methods have been devised, and it merely remains to set one's self to work.—*La Nature.*

THE LIGHTING OF FIFTH AVENUE, NEW YORK.

ABOUT a year and a half ago the low tension system of street lighting was introduced for the first time in New York on Fifth Avenue. It had been found that some such device must be resorted to, for series arc lamps were little demanded on that avenue for commercial purposes, and the expense of laying the wires for conduits for street lighting alone was so great as to be practically prohibitive. Accordingly the Edison Illuminating Company solved the difficulty very satisfactorily by employing a low tension system, in which a pair of arc lamps on each post were used instead of a single lamp with dead resistance, as had been the case in previous attempts at low tension arc lighting. Each of these lamps, which were of the Bergmann type, manufactured by the General Incandescent Arc Light Company, took five amperes at approximately 50 volts, so that practically the same amount of energy was used as in the high tension arc lamp on the series circuit. The low tension system also possessed a number of advantages over its older rival. In the first place, it was possible to connect the lamps directly to the Edison low tension mains, thus effecting a great economy and adding to the convenience and flexibility of the system; secondly, the light was more effective on account of better diffusion, as the casting of shadows was practically obviated.

An ornamental post was employed made in three parts, the base, the shaft and the arm section. Instead of placing the resistance in the hood of the lamp, it was located in the base, and the lamps were lowered and raised from within the shaft, to which access was had by means of a door in the base, the key of which was carried by the trimmer. The lamps are fed by a sliding contact, so that when they are lowered the current is entirely shut off and the trimmer is perfectly safe from even a low tension shock. The lamps are supplied from the mains by the ordinary house service method, wires running through the gas pipe which forms the center part of the shaft.

One of the great advantages of this system of lighting is the ornamental appearance of the posts and the lamps, which greatly surpass in this respect the older type of series lamp. This system has been found to operate most satisfactorily during the past eighteen months, and the only criticism passed upon it was that the avenue was not as brilliantly lighted as had been anticipated. The Edison Company recently decided to overcome this difficulty by doubling the number of lamps, and accordingly have inserted at the center of each block another post carrying two lamps. There are now 114 posts, which, with two lamps each, makes a total of 228 lamps. This has had the desired effect, and as may be seen from the illustration given herewith, Fifth Avenue is one of the most brilliantly illuminated thoroughfares in the city. At the same time the light is much more soft and pleasing than that which is given by high tension lamps.—*Electrical World.*

ELECTRIC LIGHTS, FIFTH AVENUE, NEW YORK.

ELECTRIC SIGNALING WITHOUT WIRES.*

By W. H. PREECE, C.B., F.R.S.

WHAT is electricity? Few venture to reply boldly to this question, first, because they do not know; secondly, because they do not agree with their neighbors, even if they think they know; thirdly, because their neighbors do not agree among themselves, even as to what to apply the term. The physicist applies it to one thing, the engineer to another. The former regards his electricity as a form of ether, the latter as a form of energy. I cannot grasp the concept of the physicist, but electricity as a form of energy is to me a concrete fact. The electricity of the engineer is something that is generated and supplied, transformed and utilized, economized and wasted, meted out and paid for. It produces motion of matter, heat, light, chemical decomposition, and sound; while these effects are reversible, sound, chemical decomposition, light, heat, and motion reproduce those effects which are called electricity

Faraday's immortal researches, Clerk-Maxwell's prophetic investigations, and Hertz's convincing experiments, have definitely and conclusively proved the existence of one medium throughout all space, called the ether, through which waves of energy, called radiations, are propagated with the same velocity, but in different forms and with different frequencies, although all of the same character. At one end of the scale we have actinic disturbances producing photographic impressions; at the other end of the scale electric waves producing electromagnetic disturbances, while the immediate radiations give light and heat. Actinic waves are extremely minute and number many millions per second, electric waves are very long and may number only hundreds per second. Like light waves, they are propagated in straight lines, they obey the laws of reflection, they are refracted, they are subject to interference, and they may be even polarized.

We have to consider electric waves to-night, and I want to show you how we are gradually, by patient plodding, creeping along toward the period when I hope we shall be able to make real, practical use of such electromagnetic disturbances.

If we take a conductor through which a rapidly alternating current is being supported by any means, it throws the ether which surrounds it into oscillations. Energy is thus radiated away in electric waves. These electric waves spread out in all directions, as do waves of light, and if they fall on similar conductors properly placed and sympathetically prepared, these waves of energy are transformed back again into alternating currents which give evidence of their presence. Their presence is indicated by a telephone if the frequency of the alternating currents is brought within the range of the ear. Hertz and his followers experimented with waves of much shorter length, and with sparks in air, but all my experiments have been made with telephones and with waves comparable in frequency with those of sound.

The prime source of energy has been either a steam engine or a galvanic battery. This has produced, by suitable machinery, rapidly intermittent or alternating currents which have been transmitted through a primary circuit. At some distance away from this circuit there has been a secondary telephone circuit, and between these two circuits the only connecting medium has been the ether, which has been thrown into electric oscillation, and it has been across this space that I have been signaling without wires. In all cases, the primary currents were of such a frequency as to produce a musical note in the telephones fixed in the secondary circuit, which could easily be read if sent in the dots and dashes of the Morse code.

Signaling through space is very fascinating. I have now for ten years been steadily investigating the subject. In 1884, messages sent through insulated wires, buried in iron pipes in the streets of London, were read upon telephone circuits erected on poles 80 feet away on the housetops. It was imagined this must have been due to accidental connections, or to earths, or to any other cause but the true one, namely, electromagnetic induction, or the influence which one conductor conveying currents exercises on another parallel to it, when separated by a dielectric, or by mere space, that is, by the ether.

It is very difficult to convert the human mind from one mode of thought to another. We have been so trained to regard currents of electricity as something

* A paper recently read before the Society of Arts, London. From the *Journal* of the Society.

flowing in one complete unbroken circuit, that their temporary condition as waves of energy in space is difficult to realize. One irresistibly endeavors to trace them to earth conduction, to leakage, to contact, or to some more well known cause. Ten years of unremitting experiment have, however, proved the effects I am bringing before you to be due, primarily, to radiation, and not to conduction.

In 1885, a very exhaustive series of experiments was made for me by Mr. A. W. Heaviside, in the neighborhood of Newcastle, to find out how far the distance between the wires affected the results. Ordinary telegraph working currents produced disturbances at a distance of 3,000 feet, while effects on parallel lines of telegraph, 10¼ miles apart, between Durham and Darlington, were perceptible. Distinct speech was carried on through a distance of one quarter of a mile. We even obtained indications of current between the east and west coasts, 40 miles apart, but these observations were vitiated by conduction through the large network of telegraph wires between those two places. I brought the subject before the British Association at their meeting in Birmingham in 1886. The district between Gloucester and Bristol, along the banks of the River Severn, was then selected, where for a length of 14 miles, and at an average distance apart of 4·5 miles, no intermediate disturbing conductors existed. I was able to experiment with complete metallic circuits, the return wires passing far inland, in the one case through Monmouth, and in the other through Stroud. Weak disturbances were detected. These experiments were repeated, with more experience and greater success, in 1889. Similar experiments were conducted along the valley of the Mersey. A new trunk line of copper wires that was being erected between London and the coast of North Wales was then experimented upon, and some interesting results were obtained in the district between Shrewsbury and Much Wenlock, and between Worcester and Bewdley.

An admirable series of experiments were made for me in the same year, by Mr. Gavey, near Portheawl, in South Wales. There we have a wide expanse of sand well covered by the tide and giving the opportunity to observe the effects in water as well as in air. Squares of insulated wire, 1,200 yards long, were laid side by side at various distances apart, and smaller squares were suspended above each other on scaffold poles. The effects were observable equally in air and water. The results were absolutely conclusive that we were working with the so-called electromagnetic induction, and all subsequent experience has confirmed this conclusion.

These further experiments were brought before the British Association at Manchester in 1887.

Thus the theory of the thing had been thoroughly thrashed out, and it only waited for some convenient opportunity to give it a practical test.

When the Royal Commission to inquire into electric communication between the shore and lighthouses and light vessels was appointed in June, 1892, the question was started. Here was the opportunity. My proposal to test this means of communication in a practical way was submitted by the postmaster-general to the treasury. The expenditure was sanctioned, and the experiment made. The results were submitted by me to the Electric Congress which was held in Chicago in August in 1893.

The Bristol Channel proved a very convenient locality to test the practicability of communicating across a distance of three and five miles. Two islands, the Flat Holm and the Steep Holm, lie off Penarth and Lavernock Point, near Cardiff, the former having a lighthouse upon it. On the shore two copper wires weighing 400 pounds per mile, forming one conductor, were suspended on poles for a distance of 1,267 yards, the circuit being completed by the earth. Experience justified the assumption that the earth acts as a conductor, and that it practically replaces the fourth side of the rectangle used in the previous experiments. We have not yet determined the actual position of the resultant line of this earth side, but further experiments are being made. On the sands at low water mark, 600 yards from this primary circuit and parallel to it, two ordinary gutta percha covered copper wires and one bare copper wire were laid down, their ends being buried deep in the ground by means of bars driven in the sand.

One of the gutta percha wires was lashed to an iron wire to represent a cable. These wires were periodically covered by the tide which rises here at springs to 33 feet. On the Flat Holm, 3·1 miles away, another gutta percha covered copper wire was laid for a length of 600 yards.

There was also a small steam launch having on board several lengths of gutta percha covered wire. One end of such a cable, half a mile long, was attached to a small buoy, which acted as a kind of float to the end, keeping the wire suspended upon or near the surface of the water while the launch slowly steamed ahead against the tide. It was paid out and picked up in several positions between the primary circuit and the islands.

The apparatus used on shore was a two horse power portable Marshall's steam engine, working a Pike & Harris' alternator, sending 192 complete alternations per second at a voltage of 150, and of any desirable strength up to a maximum of 15 amperes. These alternating currents were broken up into Morse signals by a suitable key and sent along the primary circuit. The signals received on the secondary circuit produced sound and were read on a pair of telephones—the same instruments being used for all the experiments.

The object of the experiments was not only to test the practicability of signaling between the shore and the lighthouse, but to differentiate the effects due to earth conduction from those due to electromagnetic induction, and to determine the effects in water.

It was possible to trace, without any difficulty, the region where the signals ceased to be perceptible from currents, due to earth conduction, and where they commenced to be solely due to electric waves. This was found by allowing the paid out cable, suspended near the surface of the water, to sink. Near the shore, no difference was perceptible, whether the cable was near the surface or lying on the bottom, but a point was reached where all sounds ceased as the cable sank, but were recovered again when the cable came to the surface.

The total absence of sound in the submerged cable rather surprised me, and it leads to the conclusion, either that the waves of energy are dissipated in the sea water or else that they are reflected away from the surface of the water like rays of light. I believe implicitly in the latter explanation. Subsequently, experiments on the sands in the Conway Estuary showing the relative transparency of air and water to these electric waves tend to support the latter deduction; for, if waste of energy took place in the water, the difference would be more marked than was actually found to be the case. It was 6 per cent. only. As it is, we have ample evidence that the electric waves are transmitted to considerable distances through water, though how far remains to be found out.

There was no difficulty in communicating between the shore and Flat Holm. Messages were read. Mr. Gavey, who was making the experiment on the island, wrote me: "There was then a somewhat lengthened pause, due to a slight derangement of the machinery on the mainland, but at 2 P. M. I heard clearly and distinctly the following: 'Here Haskayne' (one of his assistants) 'with a message from Mr. Preece for Mr. Gavey.'" I was in London that day. "Then followed the announcement of the sad and sudden death of Mr. Graves, which cast a gloom over the success of the experiment. It seemed an extraordinary fact that the first readable message transmitted for such a distance by such means should announce the death of the head of the technical department."

The distance between the two places was 3·1 miles. The attempt to speak between Lavernock and Steep Holm was not so successful. The distance was 5·35 miles, but though signals were perceptible, conversation was impossible. There was distinct evidence of sound, but it was impossible to differentiate the sounds into Morse signals. We were just on the limit of audibility, and we were using our available maximum power. If either line had been longer, or the primary currents stronger, we should have spoken as was done at Flat Holm.

As the laws governing these effects were by no means so clear and conclusive as such probing and inquiring deserved, Mr. Gavey and Mr. Kempe conducted for me a very careful series of experiments near Frodsham, on the estuary of the Dee, which was found to be a more convenient locality than Conway, and the very satisfactory results obtained will shortly be published. The conditions are now so clear that, given the localities between which it is desired to communicate, it is a mere matter of calculation to show what has to be done. It would be quite easy to speak between France and England across the Straits of Dover.

There happens to be a very convenient and accessible loch in the highlands—Loch Ness—forming part of the route of the Caledonian Canal between Inverness and Bannavie, having a line of telegraph on each side of it. Five miles on each side of this loch were taken and so arranged that any fractional length of telegraph wire on either side could be taken for trial. Ordinary and not special apparatus was employed, sending messages, as before, by Morse signals, and speaking by telephone across a space of one and a quarter miles was found practical, and, in fact, easy; indeed, the sounds were so loud that they were found sufficient to form a call for attention.

The following apparatus was in use on each side of the loch for the transmission of Morse signals. A set of batteries consisting of 100 dry cells, giving a maximum voltage of 140; a rapidly revolving rheotome which broke up the current into a musical note; a Morse key, by which these musical notes could be transformed into Morse signals; resistance coils and ampere meters to vary the primary current; two Bell telephones joined in multiple are to act as receivers. For the transmission of actual speech simple granular carbon microphones, known as the Deckert's, were used as transmitters, and a current of two amperes was maintained through these and two Bell telephones in circuit with the line wire.

Any lingering fear that earth conduction had principally to do with these results was removed by making the earth's terminals on the primary circuit at one end at Inverness nine miles away and at the other end in two directions in a parallel glen about six miles away. The early experiments of 1886, in the valley of the Severn, had placed this question of earth interference beyond the region of doubt, but earth conduction, as a main factor in the results, is still believed in by critics. The function performed by the earth has been thoroughly developed in the Frodsham experiments, and will be discussed subsequently.

One very interesting fact observed at Loch Ness was that there was one particular frequency in the primary circuit that gave a decided maximum effect upon the telephones in the secondary circuit. This proves the presence of resonance, and is, of itself, a fact sufficient alone to prove the effects as being due to the transformation of electric waves into electric currents.

It is well known that every telephone has one particular note—the natural note of the disk—to which it responds better than to any other, but this resonant effect far exceeded in magnitude any difference due to the natural pitch of the disk. It was not the natural note.

Conversation by telephone, though possible, was not however practical. Still, it is something to have transmitted speech by electricity across an air space of 1¼ miles. We had this curious condition, that at some intermediate point the energy of the human voice was found side by side in two different forms—sonorous vibrations in the air and electric waves in the ether.

There is now no difficulty in communicating with outlying islands if the conditions are favorable. The Northern Commissioners of Lights are anxious to establish electrical communication with the Muckle Flugga lighthouse, at the extreme north of the Shetland Islands, but the place is so inaccessible that, though the conditions are favorable and signaling without wires is possible and simple, it would be more prudent to adopt the more expensive plan of a submerged cable. I would rather inaugurate the system nearer home, where it could be watched, nursed, and improved. Anyhow, it is something to be able to report that we have now acquired a practical system of signaling across space without the necessity of using wires.

Although this short paper is confined to a description of a simple practical system of communicating across terrestrial space, one cannot help speculating as to what may occur through planetary space. Strange, mysterious sounds are heard on all long telephone lines when the earth is used as a return, especially in the calm stillness of night. Earth currents are found in telegraph circuits, and the aurora borealis lights up our northern sky when the sun's photosphere is disturbed by spots. The sun's surface must, at such times, be violently disturbed by electrical storms, and if oscillations are set up and radiated through space, in sympathy with those required to affect telephones, it is not a wild dream to say that we may hear on this earth a thunderstorm in the sun.

If any of the planets be populated with beings like ourselves, having the gift of language and the knowledge to adapt the great forces of nature to their wants, then if they could oscillate immense stores of electrical energy to and fro in telegraphic order, it would be possible for us to hold commune by telephone with the people of Mars.

ORIGIN OF PETROLEUM.*

PETROLEUM has been known from a very ancient date. Italy, Persia, India, the borders of the Caspian Sea, Java, and North America possess petroleum springs, discovered ages ago. About 1859 the existence of large petroleum reservoirs was signalized in Pennsylvania. Contrarily to what occurs in the case of many mineral substances like coal, which are limited to certain well marked strata, the layers which furnish mineral oil belong to several very different strata of stratified earth.

Although petroleum has been studied in many countries, its origin has not yet been determined with certainty. The theories expressed on this subject may be divided into three groups, according as the origin of the petroleum is mineral, vegetable, or animal.

We shall pass in review the most important theories, concluding each by an account of the criticism directed against such theory.

(1) *Mineral Origin.*—Mendeleeff asserts that petroleum results from the action of water on the carbureted metals inside the earth. We know, in fact, that ferromanganese with a large proportion of carbon can give, when treated with acids, gases and liquids of odor and appearance somewhat similar to those of petroleum. In his original memoir, published at St. Petersburg in 1877, Mendeleeff compares the interior of the earth, especially at the extremity of the terrestrial crust, to a blast furnace at work, and demonstrates in this manner that in both cases there is a zone of carbureted metals, especially pig iron, and above a zone of scoriæ. This last supplies the material of volcanic eruptions, and causes the formation of basalts, trachytes, porphyry, etc.

In consequence of the upheavals, crevices and fissures are formed inside the earth, through which the water penetrates to the fused carbureted metals, reacts upon them and gives birth to hydro-carburets. Geologists were the first to criticise this theory. To commence the reaction immediate contact is indispensable; but this is impossible if we refer to the hypothesis of Mendeleeff. We distinguished from bottom to top a zone of carbureted iron in fusion, and above the scoria and solid mass which constitutes the terrestrial crust. The formation of fissures cannot take place unless the substance is solid and brittle—their presence is unimaginable in plastic or liquid substances. Consequently, fused metals are protected against the irruption of waters by the zone of liquid scoriæ, and mutual action cannot exist.

To overthrow this theory—called "Theory of Emanations"—as also the hypothesis of a high temperature, it suffices to observe that the place of formation of petroleum is distant from the pyrosphere. Petroleum only appears accidentally, entirely in small quantities in the eruptive masses; that found in slimy volcanoes and the fumes is, as has been demonstrated, of organic origin. Archaic rocks—which, according to the preceding theory, should be richer in petroleum because they are purely and simply the first recipients of the petroleum coming from the interior of the earth—hardly contain any at all. Besides, after exhaustion of the actual strata, new supplies of mineral oil would ascend from the depths of the earth by virtue of the pressure, and should be of a temperature greater than that of the ground in their vicinity; but such is not the case.

In 1866, Berthelot expressed the opinion that inside the earth aldehydrates are formed at the expense of carbonic acid and alkaline metals, which on contact with the water steam produce acetylene, and this last, under the influence of the temperature and pressure, give rise by condensation to the petroleum and pitchy substances accompanying.

Ten years later Bryasson demonstrated that a mixture of water vapor, carbonic acid and sulphureted hydrogen can produce petroleum.

(2) *Vegetable Origin.*—The hypothesis of the vegetable origin of petroleum has still many partisans, who assert that petroleum is produced by the decomposition of marine plants, chiefly fucoids. They thus explain the presence of salt water and rock salt; consequently, its origin is given as analogous with that of coal, peat, etc.

Mendeleeff objects, with reason, to this theory, that if the petroleums were of organic orgin, we should find vegetable remains in the strata. Now, nothing of the kind has been remarked, and it is difficult to admit that organic substances can have been transformed into oil without leaving a carbonaceous residuum. One cannot, either, admit the supposition that the carbon may have disappeared under some influences to which the oil resisted. Besides, the products of decomposition of a vegetable nature always contain benzine, and this last exists with its higher homologues in the products from distillation of cannel coal, together with carburets identical with those of the petroleum described by Schorlemmer. In America, the Silurian strata, which are very rich in petroleum, are found to contain a few layers of coal, but they are of too little consequence to admit of a relation between their presence and that of petroleum. Likewise, in Pennsylvania, coal is found with petroleum, but the first is in upper strata, whereas the petroleum contained in the Devonian strata is below the coal, and separated from

* From *Le Mercure Scientifique; Light, Heat and Power.*

it by layers of humid clay impermeable to petroleum. This hypothesis cannot be accepted with certitude.

(3) *Animal Origin.*—The hypothesis of animal origin of petroleum is the most recent. In the first place, it was asserted almost everywhere that petroleum originates in vegetable substances, because no cause could be assigned for the collection, in so limited a space, of such large quantities of marine animals. But to day this latter hypothesis is maintained by most chemists. It is for these reasons that we shall examine with more detail each of the opinions expressed regarding the animal origin of petroleum.

First, let us mention the researches of Engler ("D. Chem. Ges.," 1888, p. 1816; "Chem. Z. T." 12, p. 842), which serve as basis of the chief theories about to be examined. Engler distilled 9 hundredweight, 2 quarters, 20·674 pounds of fish oil between 320° and 400°, under a pressure which was 10 atmospheres at the beginning of the operation and then fell to 4 atmospheres. Combustible gases were passed—an oily liquid and water. By fractional distillation of this oil, Engler isolated pentane, hexane, heptane, ortane, nonane, and carburets of other classes. He obtained a raw oil of 60 per cent. of the weight of the fatty substances employed, and nine-tenths of this oil was composed of hydrocarburets. In addition it possessed nearly all the properties of natural petroleum. The gases escaping, although their composition was different from that of gases which accompany mineral oil, contained principally methane. Later, Engler distilled some thousands of mollusks and sea fish at Hamburg; he collected quantities of ammonia and nitrogenous organic bases

According to Zaloziecki, the researches of Engler are not conclusive—do not demonstrate with certainty the animal origin of petroleum—for two reasons:

(1) Its distillation dry demands a high temperature, and this condition should be eliminated in the formation of petroleum.

(2) The products distilled under pressure have only a slight analogy with the elements of natural petroleums, these products distilled not containing aromatic carburets, and especially carburets of the naphthene class, which compose the second essential portion of petroleums, and are found in all.

After having exposed the works of Engler, we come to the theory of Hofer, who, fourteen years ago, stated that the origin of petroleum was animal, and maintained his opinion with obstinacy.

The only serious objection made for a long time to the new theory was the absence of nitrogen in petroleum, for they said that the existence of nitrogen or of its combination should be demonstrated in petroleum if produced by animal decomposition.

Even geologists supported the chemists against the opinion of animal origin. Peckham, having found nitrogen in the petroleums of California, Texas, West Virginia, and Ohio, recognized the exactness of the new theory; but as he did not find this element in the petroleums of Pennsylvania (New York), he concluded that these should, on the contrary, have a vegetable origin, and with him American geologists admitted that, according to its composition, petroleum was of vegetable or animal origin. According to Hofer, however, the geological conditions of the State of New York (Pennsylvania) do not agree satisfactorily with the vegetable origin.

To appreciate the importance of the presence of nitrogen in petroleums, we must follow the different transformations of the animal substance. In decomposition of this last gases are formed, and consequently one may ask whether the nitrogen has not disappeared in the gases accompanying the petroleums. Now, the analysis of fossil gases from Pennsylvania showed the presence of 27·87 per cent. of nitrogen, which, as Hofer demonstrated, cannot originate in the air, the oxygen of which would have disappeared in oxidizement of the carbon, giving rise to CO,CO_2. These analyses have a great scientific importance; they prove that there is no relation between nitrogen and oxygen existing under the form of CO,CO_2 in fossil gases, and they make Hofer conclude that these two oxides, far from originating in the oxygen of the air, are, like nitrogen, products of decomposition of animal substances. According to Engler, the proportion of nitrogen in fossil gas of Pechelbrom (Alsace) fluctuates between 8, 9, and 17·2 per cent.; if the proportion of oxygen is found, free or combined, and then the amount of nitrogen requisite to form air, this quantity is most frequently observed to be too small, so that even in the most unfavorable hypothesis there remains an excess of free nitrogen.

In the following table are classed the analyses made by Hofer with gases accompanying petroleum. The proportion of oxygen, free or combined, is indicated in the last column but one, and the last includes the quantities of nitrogen requisite for this oxygen to form air. These quantities of nitrogen, in five analyses, were found smaller than those which compose fossil gases; consequently, the presence of this free nitrogen is due purely and simply to the decomposition of substances of animal origin.

In Table II. we find no proportion between the amount of nitrogen and that of CO_2; that is to say, of oxygen. Thus the smallest amount of CO_2 (Analysis 2) corresponds with the highest quanity in nitrogen. As for the Torrente Sillaro gas, it should be analyzed again, on account of the large proportion of iodide of ethyl as yet found nowhere.

Nitrogen exists in all fossil gases, whether these last are contained in the limestone of Ohio, Indiana, or in the conglomerates and sandstones of New York, Pennsylvania, or again, in the schistons, clays, sands and clays properly so called (Apscheron Baku, Italy); only the composition of fossil gases, collected in the holes bored, frequently changes in the space of a few days to a remarkable extent.

The presence of nitrogen in petroleums is not requisite even in the hypothesis of animal origin. The absence of this element can, according to Engler, be explained as follows: We know that animals are formed in the soft parts by a nitrogenized fleshy portion and another composed of fatty substances free from nitrogen. At the time of putrefaction of the carcasses the nitrogenous part is rapidly decomposed, while the fatty substance is distinguished by a very special stability. In support of this he mentions the existence of adipocire, or grave wax, in every grave, and the presence of fatty substances in fossils, especially in the fossil bones of the bison of America. Engler says, also, that Gumbel found, at a depth of 546,816 yards, and even more, globules of fatty substance accumulating more or less in the slime, owing to the death of animalcules, and that this chemist concludes that petroleum should often be found in nummulitic soils. Considering the ready decomposition of nitrogenous fatty substances, and the firmness of substances free from nitrogen, the decomposition of the first has made great progress, and perhaps is already concluded when that of the second commences. The gaseous products from decomposition evidently containing nitrogen have consequently been able to accumulate in some part of the porous rocks before decomposition of the non-nitrogenized substances; that is to say, the very formation of petroleum was prepared.

During later times several geologists of America—among others M. Orton—only ascribed an animal origin to petroleum in contact with limestone, but not to that mixed with sandstone and schist. To support this new hypothesis, he states that Mr. Kemp discovered that the fossil gas produced in limestone contained, like the petroleum, sulphureted hydrogen, but that this gas was wholly absent in soils containing silicates. But Mr. Hofer demonstrated that sulphureted hydrogen often originates in the decomposition of sulphates held in water, fossil gases being powerful agents of reduction hitherto not appreciated at their full value, and which hold in mines a commanding position in the formation of metallic sulphurets. Again, petroleum springs have been found in Italy with water containing sulphureted hydrogen, although the petroleum was not in contact with limestone, but with silicates. In short, both Engler and Hofer admit for petroleum and ozokerite, or fossil wax, an animal origin. The study of the first layers of petroleum discovered, and the transformation, through heat and pressure, of the fatty substances into a petroleum-like product, without any formation of carbonaceous residuum or appreciable loss of gas, are in favor of their claims.

The first part of the problem, then, according to these chemists, is solved. But they neglect or omit the causes of the transformation and the manner in which it has occurred. This leaves the second and more important part of the problem—as to how the petroleum was found—still unsolved. The works remaining to be examined, especially those of Zaloziecki and Schsenius, have as their principal object the discovery of the solution to this part of the problem.

Let us summarize the theory of Zaloziecki. He supposes a slowly progressive decomposition of the carcasses accumulated in maritime districts under the strong agency of sea currents. There are two phases in this decomposition—putrid fermentation and bitumenization, with change of exterior conditions, stratification and the inaccessibility of air. By bitumenization we mean a gradual destruction of the fatty acid molecules under the actions of high temperature, pressure and time, this decomposition occurring with formation of carbonic acid and carburets, saturated and non-saturated. These last, subjected to secondary influences, were condensed and polymerized, producing aromatic carburets and hydrozets of these. In the analogies employed by Zaloziecki, petroleum and fossil wax are products from the decomposition of animal substances, just as coals are the remains of vegetable substances, and the various degrees of bitumenization, adipocire, ozokerite, and petroleum are set parallel with the various states of decomposition of vegetables, peat, lignite, anthracite, etc.

In studying the agencies which tend to produce the formation of petroleums, Zaloziecki shows how experience has proved that bitumen is especially abundant in sedimentary rocks; and hence its formation from animal substances is probable, as the transformation of these has taken place under the action of interior influences very like those which formed the sedimentary rocks. From this several conclusions may be drawn, the most important being that the sedimentary materials having been subjected in the course of time to changes which are still at work, the organic layers of the same epoch have necessarily undergone continual and progressive transformations. We may admit with near certainty that petroleum is absent from soils of recent formation, alluvial and diluvial, while it is found in tertiary soils. As there is no reason for denying the presence of the necessary materials for formation of petroleum at the alluvian period, we must consider time as a most potent and necessary factor.

	$^1CH_4$	N	H	C_2H_4	O	CO_2	CO	H_2S	Total.	O Total.	N for Air.
(1) Findlay, O	93·35	3·41	1·64	0·35	0·39	0·25	0·41	0·20	100	0 80	2·66
(2) Fostoria	92·84	3·82	1·89	0.20	0·35	..	0·55	0·15	100	0·81	2·70
(3) St. Mary's	93·85	2·98	1·74	0·20	0·35	..	0·44	0·21	100	0·77	2·56
(4) Muncie, Ind	92·67	3·53	2·35	0 25	0·35	..	0·45	0·15	100	0·79	2 62
(5) Anderson	93 07	3·02	1·86	0·49	0·42	..	0·73	0·15	100	0 02	3·34
(6) Kokomo	94·16	2·80	1·42	0·30	0 30	..	0·55	0·18	100	1·82	2·73
(7) Marion	93·58	3 42	1·20	0·15	0·55	..	0 60	0·20	100	1·11	3·69

Petroleum has also been found in Italy, in the province of Emilia. The terreous gases emitted by the muddy volcanoes were examined, and analysis gives the following results:

TABLE II.—FOSSIL GASES OF ITALY.

No.	Provinces.		CH_4	N	CO_2	C_2H_5I	Analyses made by
1,	Bologna	Monte Sasso Cardo	91·82	3·13	2·05	..	Fouque & Gorceix.
1,	"	Fosso dei Bagni	91·35	8·04	0·61	..	"
1,	"	Sorgente dei Bovi	92·22	2·06	5·72	..	"
1,	"	Sorgente di Marte	92·16	2·78	5·06	..	"
1,	"	Sorgente del Leone	89·42	4·61	5·97	..	"
1,	"	Poretta Vecchia	90·75	7·23	2·02	..	(?)
1,	"	Sorgente di Puzzola	91·48	6·68	1·84	..	(?)
2,	Florence	Torrente Sillaro	80·60	0·39	1·14	17·87	(?)
2,	"	Firenzuola Pietremala	96·19	2·27	1·54	..	(?)
2,	"	" "	97·48	0·77	1·75	..	(?)
3,	Bologna	" "	98·85	0·41	0·74	..	(?)
4,	Ravenna	Bergullo	98·83	0·50	0·48	..	(?)
		Rio de Bagni, Riolo	97·35	1·04	1·01	..	(?)

Poretta.

AN OPTICAL ILLUSION.

PLACE one edge of a visiting card along the line between the bird and the cage, and rest the tip of your

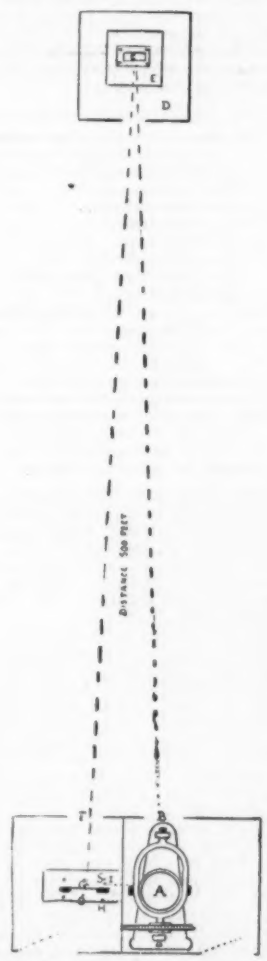
nose against the other edge of the card. Hold the card so that no shadow falls on either side. Watch the bird a moment, and you will see it go into the cage.

LONG FOCUS TELESCOPES.

By WILLIAM ROLLINS.

THE obstacle to the increase in size and number of large telescopes is the cost. How can this be reduced? As the chief expenses of a great equatorial are the mounting and the dome, with its necessary machinery, these must be given up. Several other types have been proposed, but when telescopes having focal lengths of several hundred feet are used, only the horizontal will be practical. At present this is but little used, and before its introduction can become general some new form must be given to it to overcome the difficulty of controlling the revolving mirror when the observer is stationed at the other end of the telescope many feet away. To be sure, the rate of the driving mechanism can be controlled from any distance by electricity, but for setting the mirror the observer ought to sit beside it.

I propose to reflect the light from the revolving mir-



ror to a fixed mirror distant half the focal length of the objective, and to send it back again to the observer sitting in a chair beside the driving mechanism. In the cut, A is the revolving mirror; B, the objective; C, the fixed mirror and G the eyepiece or sensitive plate. If the focal length of the objective is one thousand feet, then the fixed mirror will be five hundred feet from the revolving mirror. If the reflecting form is chosen there will be no objective, and the fixed mirror will be parabolic and placed at its focal length from the eyepiece at G. This form of mounting will be cheap, only two wooden sheds being required—one for the fixed mirror, the other larger and divided by a partition into two rooms—one for the mirror with its

driving mechanism; the other, a dark room taking the place of a camera, inside which the observer will sit while looking at the image on the plate in front of him, thus doing away with a guiding telescope. Rods and wires placed at his side will enable him to control the revolving mirror, while a slide in the partition will admit of direct access to the driving mechanism. A telescope of this type, with a focal length of five hundred feet, ought to be of value in lunar photography, even if the aperture was not larger than twelve inches. The two most probable causes of failure will be the difficulty of building a driving mechanism perfect enough to project a steady image so far, and distortion of the image from flexion of the mirrors. I propose to overcome the last by making the mirrors much thicker than is usual.—*Astronomy and Astro Physics.*

THE MUSIC OF BIRDS.

THE idea of scoring, imitating or translating the song of birds is an old one, and the Phonurgie of Father Kirchner, published in 1673, gives the first attempt of this kind.

In a very interesting article on the nightingale recently communicated to this journal, the author, Miss Beleze, in speaking of the tentatives that have been made in this direction in regard to this bird, said with good reason that they have never given brilliant results. That is true, and the assertion might be extended to the majority of other birds.

However, be it merely as a matter of curiosity, we propose to present a few very recent attempts in musical notation concerning the song of some of the birds of our country.

Honor to whom honor is due, and, since it a question of song birds, it is impossible not to begin with the nightingale. Apropos of this, let us recall the fact that, as long ago as 1787, *Les Affiches de Senlis* published the following reproduction of the song of the nightingale, taken, as it stated, from an Italian journal:

SONG OF THE NIGHTINGALE.

Tiûu, tiûu, tiûu, tiûu
Lpé tiû zqua;
Quorror pipu
Tio, tio, tio, tio, tix;
Qutio, qutio, qutio, qutio,
Zquo, zquo, zquo, zquo,
Zi, zi, zi, zi, zi, zi, zi, zi,
Quorror, tiû zqua pipiqui.

The transcriber of this song adds: "If men could penetrate the meaning of these words, they would surely see that each of them was a different expression of the secret feelings of this tender bird, since the end of its passion is the end of its song."

The French journalist does not follow up these words with any personal opinion, yet he remarks that the result is very curious if "they are allowed to be read by a woman who has a sweet and harmonious voice that conforms to the Italian pronunciation, which is different from ours."

Let us recall the pretty but fanciful translation of a French nightingale's song into human language ventured by Dupont de Nemours:

SONG OF THE NIGHTINGALE WHILE BROODING.

Dors, dors, dors, dors, dors, ma douce amie,
Amie, amie,
Si belle et si chérie
Dors en aimant,
Dors en couvant,
Ma belle amie,
Ma belle amie,
Nos jolis enfants,
Nos jolis, jolis, jolis, jolis
Petits enfants.
(*A short silence.*)
Mon amie,
Ma belle amie,
A l'amour,
A l'amour ils doivent la vie,
A tes soins ils devront le jour.
Dors, dors, dors, dors, dors, ma douce amie,
Auprès de toi veille l'amour,
L'amour,
Auprès do toi veille l'amour.

Such, says the poet, is the ground and spirit of the song, which, according to the sensitiveness of soul of the singer, is subject to many variations, for it must not be thought that all individuals sing exactly the same couplets, any more than it must be thought that they perform precisely the same actions. They have the same sentiment and manifest it in a manner that is not without analogy, that is all.

Less fanciful, Guésneau de Montbéliard, in speaking of the nightingale, has, with as much poetry, set forth "the incomparable resources of its voice: piercing single breaths; quick and light beatings; outbursts of song in which clearness is equal to volubility; an interior and dull murmur, which is not appreciable to the ear, but well adapted for increasing the effect of the appreciable tones; precipitate roulades, brilliant and rapid, articulated with force and even with a harshness in good taste; plaintive accents trilled with softness; notes sustained without art, but brimful of soul; enchanting and thrilling sounds that seem to come from the heart and that make every heart palpitate, and produce in every one who is sensitive so agreeable an emotion and so touching a languor."

The skylark, the "messenger of the dawn," the national bird of the Gauls, is the songster of the harvest-time and the only bird that sings while on the wing.

In measure as it ascends skyward, almost vertically and with successive bounds, it strains its voice. Its song bursts forth in sweet and vibrating melodies, and it is still heard while the eye seeks it in vain in sun-lit space.

"No throat," says Toussenel, "can compete with that of the skylark in richness and variety of song, fullness and softness of *timbre*, steadfastness and range of sound, and flexibility and untiringness of the vocal cords. It sings for hours at a time without stopping for half a second, ascending vertically to a height of three thousand feet in tacking about in the regions of the clouds in order to reach a greater height, and without any of its notes being lost in this extensive journey."

Alongside of these songsters of merit, let us place a few other birds not so well endowed and whose discordant screaks, such as those of the sparrow, or whose monotonous notes, like those of the cuckoo, it is easier to score.

The sparrow makes its cry heard all day long, but it is especially in the morning, at sunrise, that it is most lavish of it, and it must be confessed that the sound is not particularly agreeable to those who are condemned to hear it.

The notes of the cuckoo are likewise limited. Who does not know those two monosyllables, *coo-coo*, which fill our woods during the first days of April, and which are so characteristic that in all countries they have served as a denomination for the bird.

Nor can the ringdove be scarcely regarded as a good musician. It is in spring, at the break of day, especially in fine weather, that this bird, perched upon the summit of a tree, makes its sonorous cooing heard.

The turtle dove, whose repeated cooings recall those of the ringdove, sings upon two plaintive, melodious notes, rendered *turtur* by Latin onomatopœia, and which harmonize very well with the melancholy of the cool and thick woods wherein it nests by preference. With the thrush we return to singing birds. Still, it is necessary to be specific, for of the four kinds common to our country, there is but one that is remarkable for its song, and from this fact is derived its name of song thrush.

It translates an exuberant gayety by couplets that are as agreeable as they are varied. Perched at the very summit of a tree, it pours forth, during the first fine days of spring, before the buds have hardly opened, its ample and harmonious notes from morning till night and for hours at a time. It sings also until the month of August, that is to say, until the time of grape gathering, after which it seems that its extreme fondness for the grape causes it to forget its qualities as a musician. As soon as the vineyards offer their ripe grapes it partakes of the latter until it "loses its head" over them, and, starting from this epoch, it no

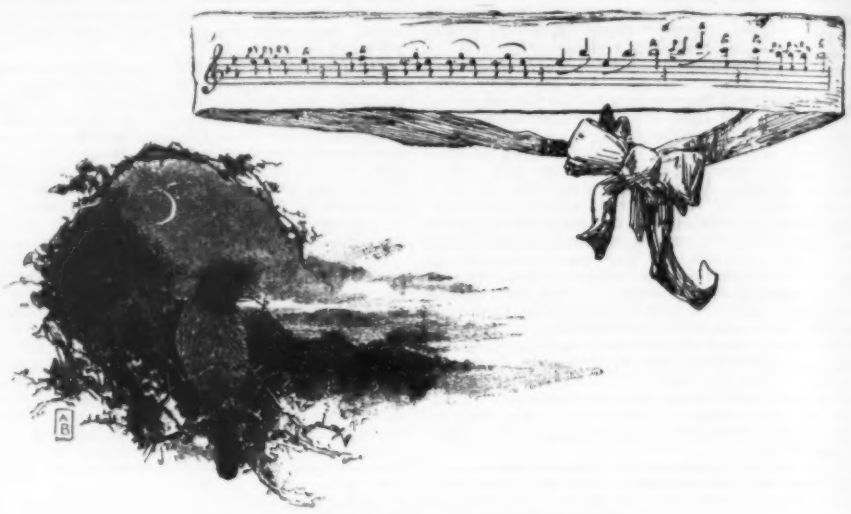


FIG. 1.—SONG OF THE NIGHTINGALE.

FIG. 2.—SONG OF THE SKYLARK.

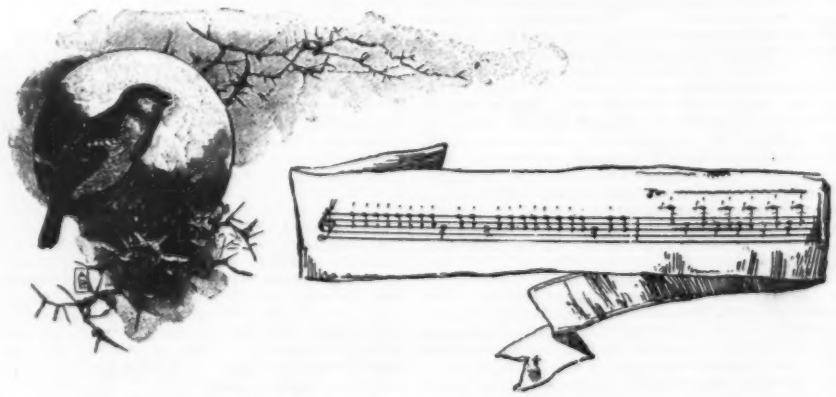


FIG. 3.—SONG OF THE SPARROW.

FIG. 4.—SONG OF THE CUCKOO.

longer utters any sound but a little hurried cry of *zip, zip*, which it allows to escape while flying away, affrighted by the shouts of the vine dressers.

The bullfinch, says Mr. V. Rendu, has great musical tendencies. It is not that its warbling is brilliant in a wild state, for, according to Guesneau de Montbéliard, its song consists of but three cries, which are not very agreeable. It begins with a whistle, followed by two more whistles, one after the other, and soon makes a greater number heard, the sound of which is pure. In measure as the bird becomes animated, its *tui, tui*, becomes more emphasized and terminates in a sort of warbling that amateurs have noted thus: *si, do, do, do, si, ré, do, do, do, do, do, do, si, ré, do.* It utters this in a graver and graver tone, almost stifled and degenerating into falsetto. In the pauses or intervals, it utters a little internal chirp, quick, abrupt, and very sharp, yet very low—so low indeed that it can scarcely be heard. The bill and throat seem to be strangers to this execution. The muscles of the abdomen are principally concerned in it; in other words, the bullfinch plays the ventriloquist.

By a peculiarity very strange in the feathered tribe, its song acquired artificially surpasses its natural song. In the hands of a skillful master, the bullfinch becomes really harmonious. When the bird organ allows it to hear, with method, mellower, finer and better sustained sounds, the bird, obedient to these lessons of taste, not only imitates them correctly, but sometimes gives a stamp of perfection to the airs that are whistled to it, without, for all that, renouncing its innate warble.

On the contrary, if it has to do with a bad musician, it repeats its lesson with deplorable accuracy. With it, memory plays an important role, and the gift of imitation seems to prevail over the musical taste, properly so called. What is something no less extraordinary, the female shares with the male the privilege of singing, and shows herself no less susceptible to this kind of training. She learns how to speak and whistle, and her voice, it is said, makes itself remarked by greater softness.

As regards "musical tendencies," there is perhaps a comparison to be made between the bullfinch and the canary bird. "If the nightingale is the songster of the woods," says Buffon, "the canary is the chamber musician. The former is master of entire nature, while the latter participates in our arts. With less strength and range of voice, and less variety in sounds, the canary has more ear, more facility of imitation, and more memory, and as it has a more attentive hearing, which is more susceptible of receiving and preserving external impressions, it becomes also more sociable, more gentle, and more familiar." It is this facility of imitation that it has in common with the bullfinch. In the portion of the song of the canary that we give herewith, one might find again some resemblance in method with the beginning of the song of the nightingale. The fact is that a canary is capable of imitating the song of any other kind of bird. It is capable also of imitating the sound of the ordinary flute, absolutely like the trained bullfinch, of repeating a few measures of a popular air, and even of learning how to pronounce a few words. It must be added, however, that such results cannot be obtained without difficulty.

In the beginning we quoted a fanciful translation that has been made of the song of the nightingale. With this interpretation may be compared that given of a few birds in certain districts by the peasants.

The quails arrive in our region toward the end of April and the beginning of May. Shortly after descending to the ground they begin to lay, and from this moment, in the grainfields and in the grass, etc., there are heard resounding the sonorous and abrupt notes of the female that have everywhere been translated by the cry of *paye tes dettes* (pay thy debts).

The chaffinch is not a singer, but we are thankful to it for being one of the first to open our spring concerts, and, moreover, although its musical phrase is not very harmonious or greatly varied, no bird can equal it in strength of lungs. It is this that has given the idea in certain countries, especially Flanders and Belgium, of getting up song contests between the male birds of this species. Scarcely has one of the rivals uttered his cry of defiance, when the other replies with a well emphasized trill. The combat, once begun, becomes a throat to throat duel, and it is to him who will extinguish the fire of his adversary by singing loud as long as possible. The contest thus lasts for hours. The last trill decides the victory, and such is the obstinacy of these musical combats that it is not rare to see the conqueror fall stone dead after a supreme effort to uphold the honor of its reputation.

During the winter the chaffinch, which remains with us, maintains silence, or merely utters a little oft-repeated *pick, pick.*

In Burgundy and the districts of eastern France the peasants have an amusing fashion of interpreting the song of this bird. As long as the inclement season lasts, and while the frozen earth is covered with snow and the chaffinch goes hopping about to repeat its plaintive cry before the door of dwellings, its utterance is considered as an appeal to every charitable heart, and the peasant translates it thus: *As-tu cuit? As-tu cuit?* (Hast thou cooked?)

But the chaffinch soon begins to "*Se moquer du laboureur,*" at least it is thus that its first strains are translated. Yet the bad days are still so near that the chaffinch seems to hesitate to proclaim the little value that it sets upon the services rendered, and to finish its irreverent phrase. This is not long delayed, however, and all the summer it keeps repeating: *Je me moque du laboureur? Je gagne bien ma vie sans lui.* (What do I care for the plowman? I make my living well without his aid.)

A finer musician is the goldfinch, so elegant in form, so brilliant in plumage and so petulant in gait. Each of its changes of place is accompanied with little joyful chirps, and, that no one may doubt its happiness to live, it sings from morning till night, at all hours of the day, with untiring animation.

When it is stationary, its preludes resemble a musical challenge that it is addressing to itself. It begins with simple notes, as if it did not dare at first to let itself out. As soon as it has begun, it gradually assumes boldness, elongates its phrases and balances them with the same motion that sways its body alternately to and fro, briskly sends back to itself a reply, and finally overflows with lyric enthusiasm. Its volubility then partakes of delirium. Again and again it sends forth its rapid notes, quavers in its refrains, varies its theme with infinite *capriccios*, and shows itself so truly an inspired artist that, after the nightingale, the palm must be awarded to it among our birds of song.

The linnet, also, inhabits our gardens and orchards and builds its nest, by preference, in the well tufted hedges that serve to fence them. Its song is naturally lively and varied; but it is, moreover, a bird that is easily tamed, and which, when confined with other birds, very quickly learns to imitate them. It must be

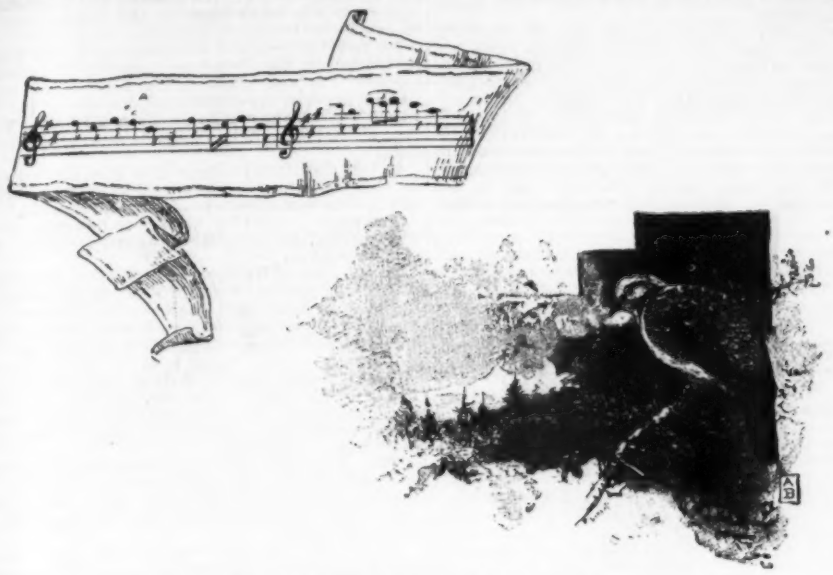


FIG. 5.—SONG OF THE RING-DOVE.

FIG. 6.—SONG OF THE THRUSH.

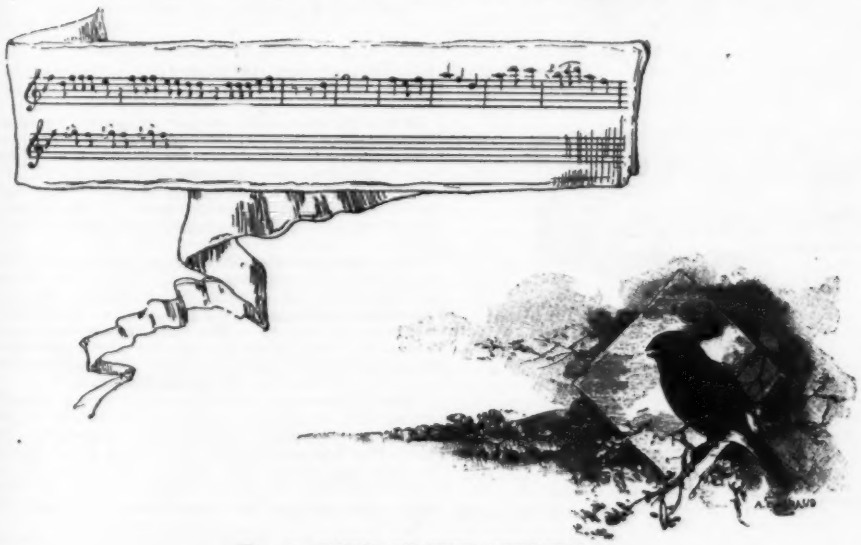


FIG. 7.—SONG OF THE BULLFINCH.

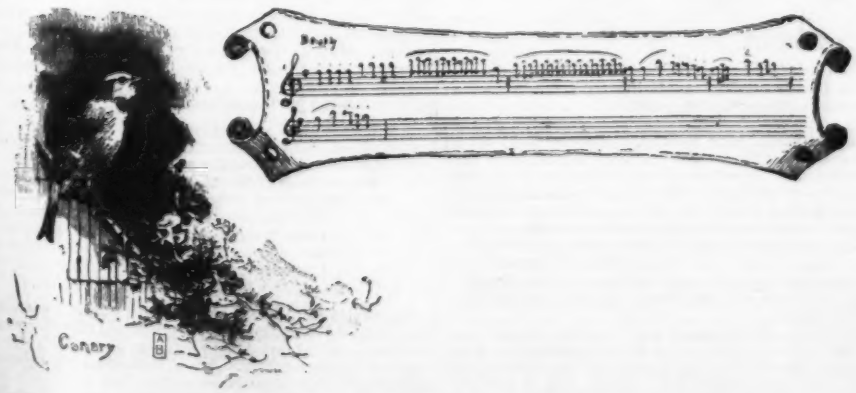


FIG. 8.—SONG OF THE CANARY BIRD.

added, however, that the song that it sings while caged is never so agreeable as that which it repeats in a state of liberty.

In this respect, it somewhat resembles the blackbird, which readily becomes accustomed to its prison, and which easily remembers the airs that are taught it, but the natural song of which is far preferable to anything that the science of the ablest professors can teach it. The blackbird is not generally appreciated as it deserves to be. We observe in this bird only a black plumage, an unsociable disposition and a vulgarity that attracts no attention. Nevertheless, it is one of our ablest songsters, one of the virtuosos that we never hear without pleasure, and which in the grand concert of the groves fulfills its part with a spirit full of lyricism. Winter is not yet over when it, along with the song thrush and the skylark, is one of the first to salute the return of the sun with its limpid and sonorous notes. Its music starts with the first

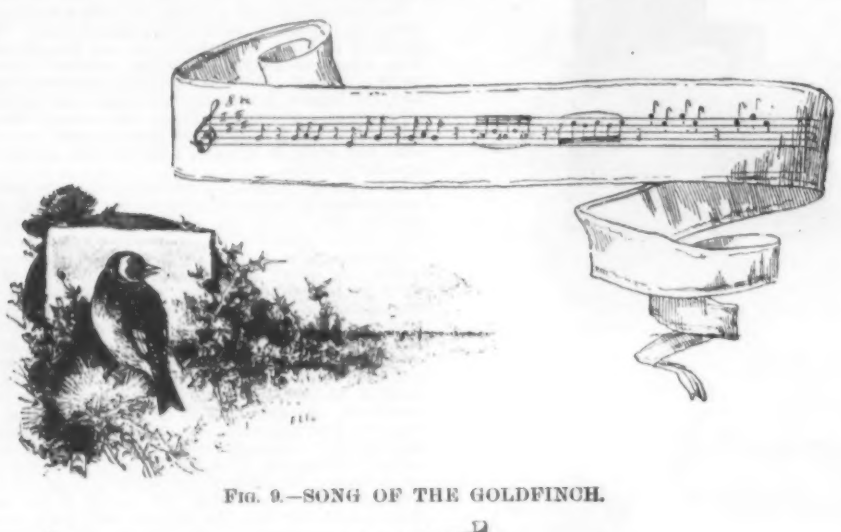


FIG. 9.—SONG OF THE GOLDFINCH.

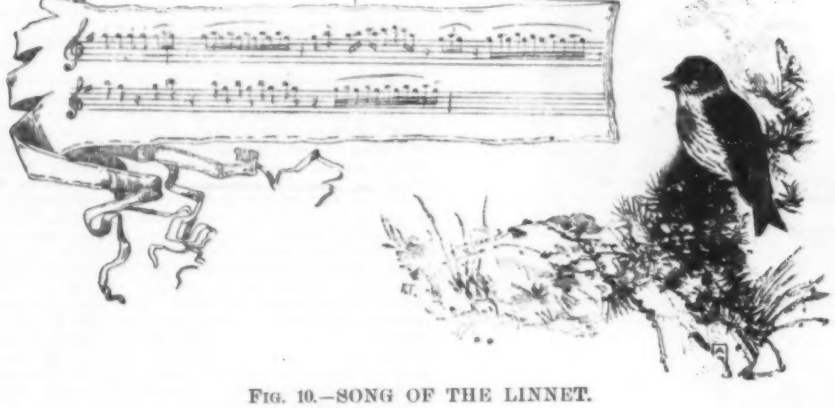



FIG. 10.—SONG OF THE LINNET.

FIG. 11.—SONG OF THE BLACKBIRD.

pleasant days of February. When spring arrives, it celebrates it with its warbling, which it prolongs far into the fine season while many others are silent. It is a dilletante whose throat is always ready, but, like all true musicians, it has its hours of harmony. It reserves its richest accords for morning and evening and also for its mate and her brood. These it enchants for hours at a time without interruption. At the latter end of the season only, it preserves silence, or to speak more correctly, no longer utters anything but a calling cry.

We have accompanied the estimate of the song of some of our birds just given with an attempt at a musical notation of them Attempts at notation, poetical or popular translations and various appreciations often belong, one or another, to the domain of pure imagination. It will be admitted, however, that such observations sometimes present a certain interest and that they offer their little share of curiosity and physiological research.—*La Science en Famille.*

FACTS ABOUT SUGAR.

By ROBERT MITCHELL FLOYD.

WHEN we know that only four centuries ago, during 1497, appeared the first authentic account of sugar being introduced into England, we cannot but marvel at its cheapness of production and universal use by all classes and peoples

Like many other things in everyday use, its early history is very vague, and though ancient Jews are credited with having knowledge concerning it, yet no mention of sugar whatever is found in the Scriptures. All writers seem to agree that the candied or granulated particles, resulting from boiling the juice of a reed or grass—sorgho, now known as sorghum or Chinese sugar cane, *Sorghum nigrum* were first used in the Celestial empire and date back prior to all records, and was in use many centuries before it was in use in India or Arabia. Among the Grecians, at a very early date, it was used in medicine and spoken of as the very costly drug "Indian salt."

Later on sugar confections were received from Arabia and Persia at Rome and Greece, but were held at so high a value that they were only used on very rare occasions by the most wealthy citizens. It is said Nearchus, one of Alexander the Great's admirals, while in the East Indies, 325 B. C., discovered large quantities of sugar, which he brought over with him.

Pliny also mentioned sugar in his writings as "a kind of honey from cane," and many curious stories have come to us regarding the penetrating into the jungles of Arabia, by the early explorers, in the hope of finding "honey grass."

As early as A. D. 625 sugar was brought from Asia, and in 1150 it is mentioned as being received in large quantities in Europe. It is supposed that about 1138 seed cane was introduced into Sicily, and in 1420 cultivation was attempted in Spain and Madeira. Early following the discovery of America seed cane was sent to San Domingo, where it was successfully raised, and in 1510 plantings were sent to Brazil and to the Barbadoes.

The introduction of sugar cane into the United States, or that part of it now known as Louisiana, must be credited to the Jesuit priests who came from San Domingo in 1751. In 1758 the first plantation and sugar mill was established on the present site of the city of New Orleans by Monsieur Du Breul.

No material progress was made until 1794, when the revolution in San Domingo brought to Louisiana a number of refugee planters and their slaves, and with them a superior species of cane, known as the Creole, which was only grown in the French islands. To these men we owe the first progressive movement in this industry.

In 1805 plantings of sugar cane were made in Georgia by Gen. Oglethorpe, whose success drew the attention of planters throughout his State and Florida.

The name "sugar" is Eastern in its origin, as shown by: Persian, shakar; Hindostanee, schukar; Arabic, sakaar, sokkar.

At the time of its early introduction into England sugar was written sugre. True sugar is largely produced from sugar cane—*Saccharum officinarum;* sorghum, *Sorghum nigrum;* sugar beet or mangel-wurzel, *Beta vulgaris;* sugar maple, *Acer saccharium.*

We use the term "true sugar" in distinction to the chemical results produced from many different materials; as, for instance, starch, changed by and to a sweet substance and called glucose or grape sugar, and others known as sugar of lead, sugar of milk, sugar of malt, sugar of manna, etc.

The growing sugar cane in our Southern States is not unlike our common field corn, with its tall stalks and long, waving green leaves. It is planted in rows about four to six feet apart, from cuttings of the cane—not from seed.

During the last part of October the cane is ready for harvesting; then the exciting period of a sugar plantation life begins, for as frost is expected at any moment, and as it kills the cane, as far as sugar making is concerned, all work is done with a rush. At daybreak swarms of negroes enter the fields, each armed with a sharp cleaver-like knife; with its back they break off the tough leaves and then, with a quick stroke, the stock is cut close to the roots and thrown to the ground, where it is picked up by the women, whose duty it is to gather and to carry it to the teams, which wheel it away to the grinding mills. The grinding consists of running the stalks of cane between huge iron rollers and is conveyed through pipes to the boiling rooms, where the first process of sugar making is begun.

From the time the first cane is cut and until all has been carted in there is a fever of excitement among the workers which seems even to stir into action the sleepy mules. Every one is happy, the sick and convalescent, both white and black, all throng to the boiling room to drink the sweet, delicious juice of the cane and also the warm sirup liquid from the kettles, which is supposed to kill all the ills that are known to be.

More than one hundred years ago a Louisiana poet wrote his appreciation of the cane juice and its benefits to man:

"While flows the juice mellifluent from the cane,
Grudge not, my friend, to let thy friends each morn,
But chief the sick and young at setting day,
Themselves regale with oft repeated draughts
Of tepid nectar; so shall health and strength
Confirm thy negroes and make labor light."
—*American Grocer.*

PURIFICATION OF SEWAGE AND OF WATER BY FILTRATION.

A PAPER upon this subject, prepared by Hiram F. Mills, A.M., C.E., for the International Engineering Congress at Chicago, contains so much that may be put to practical use wherever artificial means are necessary for a sufficient supply of pure water that we reprint the most important parts of the paper from the *Transactions of the American Society of Civil Engineers.*

Six years ago the State Board of Health of Massachusetts began experiments to supply the deficiency that was found to exist in the knowledge of the engineering profession upon the subject of filtration of water and of sewage. The ends in view were the prevention of pollution of streams, the purification of domestic water supplies and the general preservation and improvement of the public health.

The objects were not to make a better looking water or one that would be better adapted for use in steam boilers or for certain manufacturing purposes, but to learn the best methods of removing those impurities in drinking water that may be injurious to health, and, if possible, to purify sewage, so that the effluent may with safety be turned into a drinking water stream.

To supply knowledge upon these points and others pertaining to the purity of water supplies, the Experiment Station of the State Board of Health of Massachusetts was established at Lawrence in 1887. Some of the more important general results of the six years of careful investigation will now be presented.

Some idea of the extent of the laboratory work in the Department of Filtration may be conveyed by the following statistics:

There have been analyzed chemically:

1,700 samples of sewage applied to filters;
6,400 samples of effluent from filtered sewage;
400 samples of water applied to filters and
970 samples of filtered water; also,
611 samples of substances applied to filters and flowing from them, for the purpose of determining the effect of filtration upon various substances contained in sewage, making a total of 10,081 chemical analyses of samples connected with filtration.

Bacterial samples of sewage and effluent corresponding with 6,770 of the above chemical samples were examined, and about 4,000 such samples which were not examined chemically. Nine thousand other bacterial samples were examined in connection with filtration.

Samples of sand used in filters examined for bacteria numbered 880, making a total of 20,650 bacterial

examinations connected with filtration. There have been made 3,700 comparative species determinations of the bacteria in water before and after filtration.

When this work was commenced it was definitely known that no nitrification or complete oxidation of nitrogenous organic matter would take place without a current of electricity or the presence and co-operation of organic life. Robert Warington had found by numerous ingenious experiments that nitrifying organisms were to be found abundantly in soil, and it had been concluded that soil was essential to a filter bed; but the experiments of the State Board of Health show that nitrifying organisms are contained in the several kinds of drinking water supplies of all parts of the State and probably in all sewage, and that into filter beds of sand or gravel containing no soil they are after a short time introduced in sufficient numbers by the sewage; hence that soil is unnecessary for this purpose.

Organic life alone cannot produce nitrification; there must be present free oxygen. Unlike most drinking waters, sewage contains no free oxygen, if any air enters it, the oxygen is absorbed by the carbon of the organic matter; and in order that nitrification may take place there must be provided an excess of oxygen beyond that which will be readily taken up by the carbon.

The circumstances that bring most clearly to mind the essential conditions of intermittent filtration are these: a bed of gravel stones as large as robins' eggs, having an abundance of nitrifying organisms attached to each stone, has sewage poured over it for a short time; after the sewage has settled away, every stone it has reached is covered with a thin film of liquid in contact with air and enveloping the nitrifying organisms. Then nitrification takes place rapidly and with great completeness. A single hour will make a marked change in the character of the adhering liquid.

After a few hours another charge of sewage distributed over the filter will mingle somewhat with the former adhering liquid and cause it to move downward. If this charge is too abundant, a part of it may flow too rapidly through the large interstices between the stones and reach the outlet drains without being completely nitrified. This condition limits the amount that can be purified by coarse materials. The air spaces are larger than necessary, and the area of surface is small. By decreasing the diameter of the stones to one-tenth of their present diameter we may still have the same amount of air and water space and ten times the surface to which the water may adhere. In this case the air spaces between the films, though very much smaller than before, are sufficient to supply the oxygen necessary for nitrification, if we allow sufficient time between applications for the sand to become drained. It is, however, evident that if we continue diminishing the diameter of the grains of material we shall reach a condition in which the films of water adhering to the grains will occupy the whole space; there is then no room for air, and nitrification cannot take place. Sand in a filter bed that remains saturated after draining 24 hours is of little value and may be very objectionable.

Up to the present time the experiments of the State Board of Health indicate that the sand of even grain that presents all of the conditions most favorable for the very complete purification of sewage has a diameter of grain of about two-tenths of a millimeter, or about eight-thousandths of an inch.

The more even in size the grains are the better, but as we rarely find a sand in which some of the grains are not many times the size of others, and as the conditions for nitrification depend more essentially upon the finer grains of the mass, we have found it more intelligible to classify sands by the finer 10 per cent. of their grains, and in thus classifying sands we should say that sand presents the conditions most favorable for very complete purification of sewage, the finer 10 per cent. of whose grains has diameters equal to and less, but not much less, than 0·2 mm.

In soils, the organic matter, which is much finer than this, makes up a considerable part of the finer 10 per cent. of the particles, and this, sticking to the other particles, decreases the air and water spaces to a greater extent than would appear from the mechanical analysis; hence, while a filter bed made of soil whose finer 10 per cent. has diameters equal to and less than $\frac{2}{1000}$ mm. will be entirely ineffectual in purifying the smallest amount of sewage, one made of clean sand, whose finer 10 per cent. has diameters equal to and less than $\frac{1}{10}$ mm., may satisfactorily purify for years 30,000 gallons of sewage per acre daily.

With the kind of sand indicated above as being most favorable for very completely purifying the largest amount of sewage, the quantity that may be permanently applied to filters having a depth of 5 ft. of such sand is found to be about 100,000 gallons per acre daily.

The very complete purification here referred to produces an effluent chemically as good as many drinking waters, having in 100,000 parts about 0·0020 part of free ammonia and about 0·0130 part of albuminoid ammonia, the former being but $\frac{1}{10}$ of 1 per cent. and the latter but 2 per cent. of the amount in the sewage. Nearly all of the organic matter of the sewage is burned up, forming in the effluent soluble nitrates to the extent of about 1·8 parts in 100,000. Bacteriologically, the results are even more remarkable, there remaining in the effluent less than 1 in 10,000 of the number applied in the sewage. The appearance of the effluent is that of a bright, clear spring water.

With finer sands similar results may be obtained with decreasing quantities, one-half of the quantity being filtered by sands of whose finer 10 per cent. the maximum grains have diameters of $\frac{5}{100}$ mm., and excellent purification may be obtained with sands so fine as to allow the application of only 25 000 gal. per acre per day. In fact, with the finer sands, having a proper daily charge, the bacteria of the sewage may be more completely removed than with the sand allowing the greatest amount to be purified chemically.

With the material best adapted to the purification of large quantities of sewage, there is a deposit of nitrogenous matter in the upper layers amounting to about 15 per cent. of all of this kind of matter applied in the sewage. The other 85 per cent. is oxidized and passes off in solution as nitrates in the effluent. The effect of this deposit on and near the surface is to decrease the air space between the grains of sand and increase the amount of water continually held by these layers; thus in time preventing sufficient change of air in the layers beneath. Continued efficient action may be had by frequently raking over the surface to the depth of 1 in.; but there comes a time when this upper inch should be removed and replaced by clean sand. With the full complement of 100,000 gal. per acre daily of such sewage as has been filtered at Lawrence, the upper layer 1 in. in depth should be replaced by clean sand once in about eight months. With other rates of application of sewage, about 1,000 gal. of sand should be replaced for each 1,000,000 gal. of sewage applied.

The sewage that has been used upon the filters of the Experiment Station at Lawrence is pumped from one of the main sewers above where manufacturing wastes enter, and where the sewage, coming from stores and from the homes of about 10,000 people, may be regarded as ordinary city sewage, including storm water. The sewage is drawn through a cylindrical strainer lying horizontally and diagonally across the sewer a few inches above the bottom. This strainer has many holes ¾ in. in diameter. Lying as it does between the bottom and the top of the stream of sewage, it is probable that the sewage drawn through the pipe does not contain as much of the fatty substances floating on the surface of such a stream, nor as much of the mineral matter moving over the bottom, as if the sewage flowed directly from the mouth of the sewer upon the filter, but quite as much of these substances as sewage separate from storm water passed through grease traps and the settling basins usually used with sewage to be filtered.

An average analysis of the sewage put upon the filters in parts per 100,000 would be about as follows: Loss on ignition, 20 parts; fixed residue, 30 parts; free ammonia, 2 parts; albuminoid ammonia, 0·7 part; and chlorine, 6 parts. One-third of the organic matter shown by loss on ignition is in suspension. One-fifth of the mineral matter and one-half of the nitrogenous matter as shown by the albuminoid ammonia is in suspension. The average number of bacteria was 800,000 per cubic centimeter.

With sewage containing more nitrogenous matter in suspension than here given, the upper inch in depth of sand would require to be replaced more frequently than above stated, and with correspondingly less frequency if the nitrogenous matter in suspension were less.

With such sewage as above described an excellent but attainable result during warm weather is an effluent whose analysis has been already given and is now repeated for immediate comparison. Free ammonia, 0·0020 part; albuminoid ammonia, 0·0130 part; and nitrogen as nitrates, 1·8 parts, and less than $\frac{1}{100}$ of 1 per cent. of the number of bacteria applied.

To obtain as good a result in a cold New England winter, it is necessary to protect the surface of the filter bed so that it will not freeze. If the sand freezes at the surface, the sewage thaws places here and there and passes too rapidly through the sand in sections, having less than the whole area of the bed; air is partially excluded and nitrification is checked. A closed shed which will keep snow and wind from the bed will be sufficient covering where the sewage used has the ordinary temperature of sewage in sewers of 45° Fah. or more.

Unprotected beds treated with such sewage may be expected to have nitrification very much checked and an increase in organic matter in the effluent shown by the albuminoid ammonia, amounting to three times the quantity found during the warm months, with a larger multiple of the bacteria.

Four such beds through the coldest months removed an average of 91 per cent. of the albuminoid of the sewage and 97 per cent. of the bacteria; but there results from the decrease in nitrification a storing of organic matter in the filter which is only partially removed in the warm months, and the permanence of the filter is somewhat impaired. If filters are to be run nearly to their full capacity, they should be protected from freezing.

Fine sand filters may have their capacity increased by excavating trenches about 5 ft. apart, 1 ft. wide and 2 ft. deep, and filling them to within 3 in. of the top with coarser sand and applying all of the sewage to the surface of the coarse sand. In winter, boards may be put on across the trenches under which the sewage will flow and, being protected from snow, it will not freeze. Sand so fine that 15,000 gal. per acre per day exceeds its capacity may thus be enabled to filter satisfactorily 30,000 gal.

The amount of sewage that may be applied at one time depends upon the size of the grains of sand and the resulting amount of air and of water held after draining. With gravel stones which retain very little water the amount applied at once should not be as great as the amount retained, otherwise some of it will flow through immediately without sufficient time for the chemical changes to take place. On the other hand, fine sands retaining a large amount of water hold but little air; and as sewage needs as much as its own volume of air for its oxidation, we have here the quantity that may be applied at one time limited by the quantity of air held by the filter when the sewage is applied.

As illustrated by the filter of gravel stones, the purification of sewage by intermittent filtration is in no essential degree a straining process; it is essentially exposing the liquid for a sufficient time in thin films upon the surfaces of solid particles having nitrifying bacteria adherent, with air in contact with the films. These are the conditions most favorable for the chemical change, which consists of burning up the organic matter and producing the harmless mineral matter which we have called the nitrates. In continuous filtration these conditions do not exist, and no such purification is possible.

It is equally true that the removal of bacteria from the liquid depends only incidentally upon straining; for example, upon straining sewage through filter paper, which is supposed to remove all suspended matter, the number of bacteria remaining in the effluent was 20 per cent. of the number applied, while the number leaving a filter of gravel stones 5 ft. deep was less than 1 per cent. of the number applied when filtering intermittently 80,000 gal. of sewage per acre daily.

Bacteria are killed by subjecting them to conditions on the passage through the filter unfavorable to their life. One very important condition is depriving them, for a sufficient time, of suitable food material. This is most effectually accomplished by burning up the organic matter in the process of complete nitrification; so that, in general, the conditions which produce the most complete chemical purification are those most favorable for the removal of bacteria. It also results that the effluent in which nitrification has been complete is unfitted to support the life of bacteria. On the other hand, water that has been boiled supplies a good food for bacteria, and if such water be treated with a small percentage of unboiled water, the bacteria thus introduced may increase in a few days to a thousand times the number then to be found in the unboiled water. If, when very completely nitrifying the sewage applied to it, a filter be flooded with water from a boiler, the following effluents from sewage will contain a much larger number of bacteria than usual.

It was found that heating the sand of a filter to 300° Fah., or more, and pouring boiling water through it caused 100 times as many bacteria to pass through it with sewage for three months as passed through a similar filter whose sand and first water had not been heated. This appears to be due to preparing the organic matter in the sand and in the water by heat, so that it is a better food for the bacteria.

It has been found that most of the bacteria that get through the filters are of kinds that live and are propagated in wet sands and underdrains. If typhoid fever germs were applied with the sewage, their lateness of development upon gelatine plates allows other bacteria to grow in such numbers or to liquefy the plates to such an extent that the typhoid fever germs, if present, can hardly be distinguished; hence, it becomes necessary to select a foreign species, not found in our sewage, having habits of life similar to typhoid fever germs, that can be readily distinguished from other bacteria; such is *Bacillus prodigiosus* which has been cultivated in large numbers and applied by the millions to the several filters.

With sands whose finer 10 per cent. had grains as large as $\frac{5}{10}$ mm. we have succeeded in passing through a few of the *Bacillus prodigiosus*, and conclude that typhoid fever germs would pass through such sands in very much reduced numbers.

With sands of $\frac{3}{10}$ mm. and less we have not succeeded in finding in effluents any of the large numbers of *Bacillus prodigiosus* applied with the sewage. These results, together with the fact that typhoid fever germs continually decrease in numbers, not only in the effluents from these filters, but even, although less rapidly, in sewage polluted waters which have not been filtered, dying out in the latter in from one to three weeks, give us confidence in concluding that filters made with these finer sands, so long as they are kept in a condition to very completely nitrify the sewage applied, will give an effluent that may with safety be turned into a drinking water stream.

Study of the working of intermittent filters shows them to be not mechanical strainers, but delicate organisms gradually growing fitted to perform the work required of them, needing time to adapt themselves to any marked change in the amount or quality of the organic matter applied to them, but regularly, and for many years, performing an astonishing amount of chemical and biological purification, if the essential conditions for their action are maintained.

Filtration of Water.—The principles of the purification of sewage by intermittent filtration are applicable to the purification of polluted water supplies, with this important difference: water supplies have not sufficient organic matter to combine readily with all of the oxygen the water absorbs from the air, consequently they contain more or less free oxygen; hence, they do not require so frequent renewal of air in the sand, and much larger quantities can be passed through the filter and find there a sufficient additional amount of air to combine with what nitrogenous matter they contain, to nitrify it through longer periods of continuous use than the still more polluted water which we call sewage.

We may in a very general way distinguish between the two by saying sewage contains fifty times as much nitrogenous organic matter as a polluted water supply. The question may then arise, can we satisfactorily purify by filtration fifty times as much water as sewage upon the same area? It may prove to be practicable in the future, but at present we will give attention to results that have been obtained when filtering about half of this amount.

One of the first steps in considering what sand to use in a filter is to determine how much water will flow through it with the available head. Mr. Allen Hazen, the chemist in charge of the Experiment Station, found the quantity that would flow through the sands ordinarily used for filtration* to be, at a constant temperature, directly proportional to the acting head, and inversely proportional to the depth or distance through the sand. He also found it directly proportional to the square of the maximum diameter of the finer 10 per cent. of the sand grains. Calling the maximum diameter in millimeters, d, the head and feet, h, the distance flowing through the sand, l, and the quantity in 1,000,000 gallons per acre per day, Q, he found the following

* Mr. Hazen also made a few experiments to aid in determining the amount of coarse material necessary for underdraining the sand, which may be summarized as follows:

QUANTITY OF WATER FLOWING THROUGH GRAVEL STONES AT DIFFERENT HEADS.

Loss of head in terms of distance through gravel.	Size of gravel stones in millimeters and inches. The finer 10 per cent. finer than—							
	Millimeters.	3	5	8	10	20	30	40	50
	Inches.	0·12	0·20	0·32	0·39	0·79	1·2	1·6	2·0
	Quantity flowing in 1,000,000 gallons per acre daily.								
0·0005	.....	4	12	22	35	90	170	280	410
0·001	.....	7	23	43	65	160	300	480	690
0·002	.....	15	43	84	130	300	490	720	1040
0·004	.....	29	82	160	230	530	790	1070	1360
0·01	.....	72	185	320	450	860	1280	1670	2150
0·02	.....	136	320	500	630	1280	1800	2310	3080
0·05	.....	300	600	920	1140	2080	2982	3734	4800
0·10	.....	530	1000	1400	1650	2850	4044	5480	6900

formula to satisfactorily express the results of his experiments with water at about 50° Fah.:

$$Q = \frac{800\ h\ d^2}{l}$$

The sand which we have found capable of very completely purifying the largest quantity of sewage having d equal to $\frac{5}{10}$ mm. would, when 1 ft. deep and with 1 ft. acting head, allow 32,000,000 galls. per acre to flow through it in 24 hours; and the same quantity would flow through any other depth if the acting head were equal to the depth. There are practical considerations that make it desirable to depend upon a less head than the distance the water passes through the sand. If there be 1 ft. acting head for a passage of 5 ft. through the sand, the maximum quantity that would flow through this sand in 24 hours would be 6,400,000 galls. per acre; but the whole 24 hours would not be available if the water be applied intermittently. With the Merrimac River water used in the experiments it was found that filling the sand with air once a day was sufficient; in which case we can count upon a steady flow through the sand for two-thirds of the 24 hours, thus passing 4,300,000 galls. per acre per day when the sand is clean; but this quantity would be still further reduced, for the water has some organic matter and some mineral matter in suspension at all times, and during the spring freshets the amount of mineral matter is very large. All of this suspended matter tends to clog the interstices of the upper layer of the filter and to allow less water to pass; hence, the sand of the filter must be coarse enough to allow the desired quantity to flow through when the upper layer is obstructed, and not make the intervals between scrapings of the surface to remove this deposit too inconveniently short.

With the water used, the sand we are considering allowed 60,000,000 galls. of water to pass through 1 acre between the times when it was necessary to scrape the surface and remove about ½ in. of sand and sediment and replace with clean sand.

When filtering 2,000,000 galls. per acre daily, the deposit had to be removed once a month in the six months from May to October, and more frequently during the spring and fall freshets. With coarser and finer sand the amount passed between scrapings was nearly in proportion to the size of the sand grains.

Sands, the larger grains of the finer 10 per cent. of which are from $\frac{1}{10}$ to $\frac{1}{5}$ mm. in diameter, and whose capacity to pass water through a depth equal to the acting head ranges from 8,000,000 to 72,000,000 galls. per acre in 24 hours, have given excellent results when filtering 2,000,000 galls. per acre per day, and the mean of these sizes has also satisfactorily purified 3,000,000 galls. per acre per day.

With filters having 5 ft. in depth of sand, whose finer 10 per cent. had maximum grains from $\frac{1}{10}$ to $\frac{5}{10}$ mm. in diameter, the chemical purification, when filtering at the rate of 1,350,000 to 2,000,000 galls. in 24 hours, was very satisfactory, both with continuous and with intermittent filtration. The following are average results in parts per 100,000:

	Free ammonia.	Albuminoid ammonia.	Nitrogen as nitrates.
Unfiltered water from the river ...	0·0070	0·0187	0·0119
River water filtered continuously..	0·0008	0·0078	0·0051
River water filtered intermittently.	0·0007	0·0075	0·0468

As before indicated, there is in drinking water nearly enough absorbed oxygen to combine with the nitrogenous organic matter to burn it up or to nitrify it, when it is brought in contact with nitrifying bacteria under conditions favorable for their action. Filling the sand with air once a day furnishes the additional quantity of oxygen necessary for very complete nitrification.

Similar chemical results may be obtained with filters having sand 4 ft. deep. With less depths the purification is less complete, but even with a depth of only 1 ft. of sand the free and albuminoid ammonia were reduced to 21 per cent. and 52 per cent. respectively, of the unfiltered water, and the nitrates were nearly doubled; still, these shallow depths cannot be depended upon to give constantly reliable results.

While the chemical change that takes place in the water when passing through the filter is important, it is much less important than the removal of bacteria. One very important effect of burning up the organic matter and forming nitrates is removing the food supply that would support the life of injurious bacteria. It is probably fair to state that the invisible vegetable kingdom of bacteria is as a whole no more injurious to man than the whole of the visible vegetable kingdom. As in the latter there are certain poisonous plants, so in the former there are a few species that cause disease in man. Of these we know but little, but as far as studied we do not find that they increase in sewage-polluted water. The temperature and food supply they find in the human body are better adapted to their propagation, and while they continue for a time to exist when turned with sewage into a stream or pond, it is probable that they continually decrease in numbers.

With the intelligent care and favorable conditions at the Experiment Station less than ¼ of 1 per cent. of the applied germs live to get through the water filters, with sands varying in depth from 1 ft. to 5 ft., and, within this limit, the deeper filters and the finer sands allow smaller numbers to pass.

The difference in the efficiency of removing these applied germs with sand 1 ft. deep, or with sand 5 ft. deep, is so small that it is evident that nearly all of the removal is effected by the upper foot of material. In fact, in a filter having 1 ft. in depth of sand which had been filtering continuously for six months the surface was scraped, and in the next ten days more than 2,000 million of *Bacillus prodigiosus* were applied from day to day. The sand was then carefully examined and found to contain 13 per cent. of the number applied, 93 per cent. of which were found in the upper ¼ in. None were found alive below the upper inch. This was not the case with the ordinary river bacteria; they were distributed throughout the sand, but with greatly decreased numbers below the upper inch.

With intermittent filtration of water, the number of germs remaining alive in the sand is very much less than with continuous filtration. Some examinations in the summer have shown the number in the upper ¼ in. to be but 1 per cent. of the number that had been applied. The ordinary river bacteria do not survive within the sand in intermittent filtration to nearly the same extent as in continuous filtration.

Long series of experiments with the filters which we regard as adapted to the filtration of water supplies have shown, immediately after, as well as before, scraping the surface a removal of more than 99$\frac{5}{10}$ per cent. of the applied germs, and if all of the disease germs like those of typhoid fever do not increase, but rapidly decrease, in filtered water, we may conclude that the $\frac{5}{10}$ of 1 per cent. of the number applied will do little or no harm.

Such results can only be obtained in actual practice by having the filters constructed with the most intelligent care, having in view particularly that the sand shall be so placed that it forms a homogeneous mass without stratification or coarse-grained channels down through which an undue quantity of water may flow; and when in use the surface should be as intelligently kept in order, so that every square foot shall continually do its allotted part of the work.

A UNIVERSAL ASTRONOMICAL CLOCK.

THINKING that a device giving the hour of all the countries of the world, instantly and without calculation, might prove of service, Mr. A. G. Jourdan has constructed the apparatus illustrated herewith. It consists of a terrestrial globe upon which the points figuring the cities are very apparent, so that they can be easily found at a glance. This globe rests upon a dome whose base is divided, parallel with the equator of the sphere, into twice twelve consecutive hours, and graduated in the direction of the rotary motion of the earth, that is to say, from west to east. Half of this universal dial is white and represents the hours of the day, and the other half is black and represents the hours of night. The globe, which is moved by clockwork inclosed in the dome, makes a complete revolution around its axis in twenty-four hours. The clock is wound up every eight days.

It results from this arrangement that when any point of the globe is situated exactly over its local hour, all the other points are necessarily opposite the hour that corresponds to them, and it continues to be

JOURDAN'S UNIVERSAL ASTRONOMICAL CLOCK.

thus as long as the globe regularly accomplishes a revolution of twenty-four hours around its axis.

The glided hand, L, indicates the local hour and corresponds to a gilded meridian, I, which passes through the place that one inhabits. When we desire to know the hour of any city whatever, we bring this city in front of us by slowly revolving the entire apparatus (which pivots upon its base). We then place the right limb of the silver plated meridian, M, which is movable and independent, upon the center of the city, and the silver plated needle, m, with which it is provided points out exactly the mean hour of it. The words "day," "night," "morning," "evening," "noon" and "midnight," indicate the moment of the day under consideration, which is designated, moreover, by the color of the dial, all the countries over the white part being necessarily in the light of day and those over the black part being in the darkness of night.

This universal clock can be used in any part of the globe; for it suffices that the hand of the local hour, which can be displaced at will, shall correspond exactly to the place that one inhabits. A gilded circle divided into 360° represents the equator, whose 0 is fixed upon the local meridian, so that the longitudes can, at will, be counted from any point whatever for an initial meridian. The movable and independent meridian, M, indicates the latitudes and zones whose separations mark the tropics and polar circles. The longitudes, whose hours are indicated by the needle, m, of the movable meridian, are read upon the equator at the crossing of the graduated limb of such meridian.

The same apparatus, without clockwork, may serve for furnishing the same data (save the local hour) by setting it previously, by hand, at the hour of the place that one inhabits. Aside from the other services that it is destined to render, its utility for teaching is indisputable.—*La Nature.*

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TABLE OF CONTENTS.

PAGE

I. ASTRONOMY.—Long Focus Telescopes.—A curious suggestion for manufacturing equatorials.—1 illustration. 13265

II. BIOGRAPHY.—The Emperor William and His Family.—1 illustration.—Biographical note on the life of the present Emperor of Germany. 13261

III. CIVIL ENGINEERING.—Cement Testing.—By SPENCER B. NEWBERRY.—A resume of different tests as prescribed in different places and by different authorities.—A valuable contribution to civil engineering. 13263

IV. ELECTRICITY.—Electric Signaling Without Wires.—By W. H. PREECE, C.B., F.R.S.—A paper on the author's experiments of the past ten years on this most interesting subject. 13269
The Lighting of Fifth Avenue, New York.—The Edison lamps on Fifth Avenue.—Constant potential arc lamps recently installed there.—1 illustration. 13265

V. GEOLOGY.—Origin of Petroleum.—Discussion of different hypotheses of the origin of petroleum oil, with numerous analyses. 13264

VI. HOROLOGY.—A Universal Astronomical Clock.—A clock giving the hour of all countries of the world without calculation, involving the use of a terrestrial globe.—1 illustration. 13270

VII. MECHANICAL ENGINEERING.—Two Hundred Horse Power Gas Engine.—A powerful tandem gas engine—Self-starting and of very quiet operation.—2 illustrations. 13261
Water Tube Boilers.—Continuation of this article, reviewing the construction of this type of boiler.—4 illustrations. 13260

VIII. MISCELLANEOUS.—Facts about Sugar.—Popular note on sugar and the incidents of its cultivation. 13269
The Music of Birds.—A curious investigation into the music of birds, with actual notes of their songs.—11 illustrations. 13266
The Name of Robert Fulton for a War Steamer.—A suggestion that the name of Robert Fulton should be perpetuated in our navy. 13268

IX. NAVAL ENGINEERING.—Speed versus Economy in Steam Vessels.—Contrast of two ships, one of double the speed of the other.—An interesting determination of relative economy. 13267
The First War Steamboat.—By Rear Admiral GEORGE H. PREBLE.—A paper on the Fulton the First, with notes on her destruction. 13259
The First War Steamer of the World.—The war steamer Fulton the First.—Full description of the vessel and characteristic illustration of the scene at her launch.—5 illustrations. 13258

X. PHYSICS.—An Optical Illusion.—A curious delusion in dioptric vision. 13265

XI. PHYSIOLOGY.—Dr. D'Arsonval's Experiments in Electro-Physiology.—Some very curious and interesting experiments by the famous French electrician.—Very fully illustrated.—6 illustrations. 13262

XII. RAILROAD ENGINEERING.—The Reynolds Saloon Locomotive.—An engine for high speed work and with a possibility of running 500 or 1,000 miles.—1 illustration. 13267

XIII. SANITARY ENGINEERING.—Purification of Sewage and of Water by Filtration.—A most exhaustive investigation on this important subject, based on experiments by the State Board of Health of Massachusetts. 13263

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PAGE
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rs, of ... 1266
B. er- on ... 1266
H. he ... 1267
ge ed ... 1268
y- a . 1268
ng v- ... 1270
er nd ... 1271
he ... 1272
on ... 1272
of ... 1273
er ... 1273
rle ... 1274
co- by er- ... 1275
or of ... 1276
of ia of ... 1276

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